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No. 177

ASTM Bulletin

NEWS—Actions on Standards; Publications; New Vice-President; Important Technical Committee Notes.

PAPERS—Stainless Steel; High Hardness Steel; Tension Tests of Metals; Elastomers; Plastics; Soil; Concrete Beam.

American Society for Testing Materials

ASTM BULLETIN

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This Issue Contains

NEWS ABOUT THE SOCIETY AND ITS COMMITTEES:

MISCELLANEOUS NEWS NOTES:

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1902—50th Anniversary Meeting—1952

ASTM BULLETIN

"Promotion of Knowledge of Materials of Engineering, and Standardization of Specifications and Methods of Testing"

TELEPHONE—Rittenhouse 6-5315 | R. E. Hess, Editor | CABLE ADDRESS—TESTING, Philadelphia

R. J. Painter, Associate Editor

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Standards Committee Approves Many New Tentatives and Changes in Standards and Tentatives

Actions Affect Steel, Alloys, Cement, Masonry, Road and Other Materials

THE Administrative Committee on Standards held its usual fall meeting at ASTM Headquarters on September 12. Action was taken on recommendations submitted by many of the Society's technical committees. A detailed list of all the revisions and new additions appears in the accompanying table. These approvals will of course be reflected in the 1951 Supplements to all Six Parts of the 1949 Book of ASTM Standards, all of which should be available within a few months.

Generally the Administrative Committee on Standards meets but once a year—about two months after the Annual Meeting. It meets more often if there is need for such a meeting. (Many members may recall the special meeting of the Administrative Committee on Standards during the Annual Meeting in New York in 1945 when travel restrictions permitted the Society to hold only a General Business Session.) However, it can and does act on committee recommendations at any time during the year by letter.

The Administrative Committee has for its functions broadly (1) to promote the standardization work of the Society; (2) to consider means of general policy concerning standardization activities, including relationship with similar activities of other bodies; (3) to consider the desirability of expansion of standardization work into new fields; (4) to review annually the progress in the Society's standardization work; and (5) to pass upon proposed new standards, proposed amendments of existing tentatives, or proposed amendments of existing standards offered between annual meetings of the Society in accordance with provisions of the Regulations Governing Technical Committees.

In carrying out its broad functions and its specific authority on committee recommendations the committee is interested in improving the editorial preparation and presentation of proposed methods of test and specifications, and has given considerable attention to the subject.

Committee officers presenting recommendations to the Administrative Committee indicate why the recommendations are being made; give a complete analysis of the vote in the committee; explain the negative votes which are quoted verbatim; and advise what action the committee has taken or proposes to take in order to reconcile the negative viewpoint. At its meetings the Administrative Committee on Standards offers an opportunity for those who have negative viewpoints to present their reasons in person, and for committee officers to be heard in support of committee recommendations. Negative voters on committee recommendations have a right to request such an open hearing at any time.

A classification of actions which can be taken by the Administrative Committee for the Society can be summarized as follows:

1. *Acceptance as Tentative:*
   - (*a*) Acceptance of Tentative Revisions of Standards
   - (*b*) Acceptance of New Tentatives
   - (*c*) Acceptance of Revisions of Tentatives
   - (*d*) Acceptance of Revisions of Standards that are being reverted to Tentatives (essentially acceptance of a new replacing Tentative with concurrent withdrawal of the Standard)
2. *Withdrawals:*
   - (*a*) Withdrawal of Tentatives
   - (*b*) Withdrawal of Standards
   - (*c*) Withdrawal of Tentative Revisions of Standards

Ferrous Metals

Steel:

A revision of the Tentative Specification for Alloy Steel Rounds Suitable for Oil Quenching to End-Quench Hardenability Requirements (A 304 - 47 T) submitted by Committee A-1 on Steel was approved, to recognize current hardenability concepts in specification form. The specifications cover hot-rolled bars of a variety of alloy steel compositions and sizes which may attain, by suitable quenching, the hardness at various locations. Hardenability is measured quantitatively, usually noting the extent or depth of hardening of a standard size and shape of test specimen in a standardized quench. In the end-quench test the "depth of hardening" is the distance along the specimen from the quenched end to a given hardness.

In order to bring abreast of commercial practices the Tentative Specifications for Quenched and Tempered Steel Bolts and Studs with Suitable Nuts and Plain Washers (A 325 - 49 T) were revised. These specifications cover quenched-and-tempered steel bolts studs and similar externally threaded parts 1–1½ in. and under in diameter, usually made of medium carbon steel and for applications where high strength is required. Suitable nuts and plain washers also are covered by these

Actions by the ASTM Administrative Committee on Standards, September, 1951

NEW TENTATIVES

Definitions of:

Terms Relating to Porcelain Enamel (C 286 – 51 T)

Method of:

Test for Sieve Analysis of Wet Milled and Dry Milled Porcelain Enamel (C 285–51 T)
Test for Resistance of Porcelain Enameled Utensils to Boiling Acid (C 283 – 51 T)
Test for Impact Resistance of Porcelain Enameled Utensils (C 284 – 51 T)
Test for Acid Resistance of Porcelain Enamels (C 282 – 51 T)
Test for Specific Gravity of Compressed Bituminous Mixtures (D 1188 – 51 T)
Test for Pallets (D 1185 – 51 T)

Specifications for:

Malleable Iron Flanges, Pipe Fittings, and Valve Parts for Railroad, Marine, and Other Heavy Duty Service (A 338 – 51 T)
Standard Nominal Diameter and Cross-Sectional Areas of Awg Sizes of Solid Round Wires Used as Electrical Conductors (B 258 – 51 T)
Extra Strength Ceramic Glazed Clay Pipe (C 278 – 51 T)
Chemical Resistant Masonry Units (C 279 – 51 T)
Oxychloride Magnesia (C 275 – 51 T)
Magnesium Chloride (C 276 – 51 T)
Magnesium Sulfate Epsom Salts, Technical Grade (C 277 – 51 T)
Crushed Stone, Crushed Slag, and Gravel for Bituminous Concrete Base and Surface Courses of Pavements (D 692 – 51 T)
Equipment for the Sampling of Industrial Water and Steam (D 1192 – 51 T)
Reagent Water (D 1193 – 51 T)

TENTATIVE REVISIONS OF STANDARDS

Specifications for:

Magnesium Ingot and Stock for Remelting (B 92 – 45)
Granite Block for Pavements (D 59 – 39)

REVISION OF STANDARD AND REVERSION TO TENTATIVE

Specifications for:

Structural Nickel Steel (A 8 – 46)
Welded Alloy Open Hearth Iron Pipe (A 253 – 47)
Welded Alloy-Steel Boiler and Superheater Tubes (A 249 – 47)
Electric - Fusion - Welded Steel Pipe (A 139 – 46) (Sizes 4 in. to But Not Including 30 in.)
Electric - Fusion - Welded Steel Pipe (A 134 – 42) (Sizes 30 in. and Over)

Recommended Practice for:

Laying Sewer Pipe (C 12 – 19)

REVISIONS OF TENTATIVES

Method of:

Sampling Boiler Water from Stationary Boilers (D 860 – 48 T)

Specifications for:

Alloy-Steel Rounds Suitable for Oil Quenching to End-Quench Hardenability Requirements (A 304 – 47 T)
Quenched and Tempered Steel Bolts and Studs with Suitable Nuts and Plain Washers (A 325 – 49 T)
Welded and Seamless Steel Pipe (A 53 – 51 T)
Seamless Alloy-Steel Boiler and Superheater Tubes (A 213 – 51 T)
Welded Alloy-Steel Boiler and Superheater Tubes (A 249 – 51 T)
Magnesium-Base Alloys in Ingot Form for Sand Castings, Die Castings, and Permanent Mold Castings (B 179 – 50 T)
Aluminum-Base Alloys in Ingot Form for Sand Castings, Die Castings, and Permanent Mold Castings (B 179 – 50 T)
Fine Aggregate for Sheet Asphalt and Bituminous Concrete Pavements (D 1073– 49 T)

WITHDRAWALS

Standard Specifications for:

Crushed Stone, Crushed Slag, and Gravel for Bituminous Concrete Base and Surface Courses of Pavements (D 692 – 49)

Tentative Specifications for:

Venetian Red (D 767 – 51 T)

specifications. Where the term bolt appears, it is intended also to include studs and similar externally threaded fasteners. The most important change in the specifications is the inclusion of the wedge test which specifies that during tension testing a 40-deg wedge shall be placed under the head of the bolt and the tension test continued until failure occurs. To meet the requirements of this test, there must be a tensile failure in the body or threads with no fracture of the head.

A revision and reversion to Tentative of Standard Specification for Structural Nickel Steel (A 8 – 46) was adopted. This specification covers high-strength structural steel shapes, plates, and bars up to 1¼ in., inclusive, in thickness, intended primarily for special use in main stress-carrying structural members. The revision shall conform to the applicable requirements of the current edition of the Tentative Specification for General Requirements for Delivery of Rolled Steel Plates, Shapes, and Bars for Structural use (A 6 – 50 T). The steel as specified shall be made by either or both of the following processes: open hearth or electric furnace.

On the revision of Tentative Specifications for Welded and Seamless Steel Pipe (A 53 – 51 T), cognizance should be taken of the wall thickness for pipe sizes 14 in. OD to 24 in. OD as covered by Table 4 of ASA B36.10-1950. Those sizes and wall thicknesses should be added to Tables III and IV of Specification A 53, with tabulated test pressures calculated on the basis of 60 per cent of the specific yield point. Furthermore, an addition should be added to the paragraph on hydrostatic test to read: "The maximum hydrostatic test pressure shall not exceed 2500 psi for nominal sizes 3 in. and under, or 2800 psi for all nominal sizes over 3 in. The hydrostatic pressure shall be maintained for not less than 5 sec."

Another action covers the reversion to tentative with revision of Standard Specifications for Welded Alloy-Steel Boiler and Superheater Tubes (A 249 – 47). A recommendation has been received from producers of this class of tubing that owing to the fact that heat exchanger and condenser tubes are ordered under this specification, the title should be made to read: "Welded Austenitic Stainless Steel Boiler, Superheater, Heat Exchanger and Condenser Tubes." In connection with this expansion of the title, changes are necessary in the text of the specification. In addition, a new grade, TP-310, will be added.

For the Tentative Specification for Seamless Alloy-Steel Boiler and Superheater Tubes (A 213 – 51 T), a revision of the title is proposed, to read: "Seamless Alloy-Steel Boiler, Superheater, and Heat Exchanger Tubes." This change will require changes in the text of the specification. The change in scope, in accordance with the change in title, will read: "These specifications cover seamless ferritic and austenitic steel boiler and superheater tubes and austenitic steel heat exchanger tubes, ..."

Reversion to tentative, with revision of the "Standard Specifications for Electric-Fusion-Welded Steel Pipe" for sizes 30 in. and over (A 134 – 42), and 4 in. to, but not including, 30 in. (A 139 – 46), has been proposed. These revisions are recommended in order to bring the specifications in line with present commercial practice. For Specification A 134, the proposed change in scope will read: "These specifications cover electric-fusion (arc)-welded straight-seam or spiral-seam steel plate pipe 16 in. and over in diameter (inside or outside as specified by purchaser), with wall thicknesses up to ¾ in., inclusive. The pipe is intended for conveying liquid, gas, or vapor." In this specification, the term "plate" is used to describe the material of which the pipe is made, and the description does not necessarily conform to the definition of "plate" as used in steel making practice. The suitability of the pipe for various purposes is somewhat dependent on the dimensions, properties, and conditions of service. In the case of Specification A 139, the scope is enlarged to read: "These specifications cover two grades of electric-fusion (arc)-welded straight-seam or spiral-seam steel pipe 4 in. and over in diameter, with nominal (average) wall thickness up to ⅝ in., inclusive. The grades of steel are pipe mill grades having mechanical properties which differ from standard plate grades. The pipe is intended for conveying liquid, gas, or vapor."

A revision in the number of tension tests in Specification A 213 and A 249 has been recommended. In the above two ASTM

specifications governing tubular products, the requirement for tension tests varies considerably. Therefore, a proposal has been submitted that this test procedure conform to a uniform practice and that the number of tests be reduced. On the basis of this, a recommendation was received that in the two mentioned specifications, the number of tension tests be reduced to a 1 per cent level where present requirements are in excess of this amount.

Malleable-Iron Castings:

The Standards Committee approved a recommendation of Committee A-7 on Malleable-Iron Castings on proposed tentative Specification for Malleable Iron flanges, Pipe fittings and Valve Parts for Railroad, Marine, and Other Heavy-Duty Service. This proposed tentative is designed to take the place of Specification A 277-44 T which over the years has been objected to by a minority of members of Committee A-7.

Non-Ferrous Metals

Wires:

A proposed Tentative Specification for Standard Nominal Diameters and Cross-Sectional Area of Awg Sizes of Solid Round Wires Used as Electrical Conductors (B 258-51 T) as submitted by Committee B-1 on Wires for Electrical Conductors has been approved. There is no standard available in the industry covering Awg sizes and giving standard methods of computing derived data such as weight, resistance, etc., which could serve as a basis for agreement between producers and consumers or other interested parties. This specification, therefore, gives formulas and rules for the calculation of standard nominal weights, resistances, and breaking strengths of such wires.

Light Metals:

A recommendation by Committee B-7 on Light Metals and Alloys, Cast and Wrought on a proposed Revision of Tentative Specification for Magnesium-Base Alloys in Ingot Form for Sand Castings, Die Castings, and Permanent Mold Castings (B 93-49 T) has been approved. The proposed changes in this specification are to add a new alloy identified as AZ91C which is now a commercial alloy. A proposed Revision of Tentative Specifications for Aluminum-Base Alloys in Ingot Form for Sand Castings, Die Castings, and Permanent Mold Castings (B 179-50 T) asks for changes in this specification making the composition limits consistent with current commercial practice.

In another action the Administrative Committee on Standards accepted the Tentative Revision of Standard Specification for Magnesium Ingot and Stick for Remelting (B 92-45). This revision was approved in order to make the specifications consistent with commercial practice and consistent with impurity limits.

Cement and Cementitous Materials

Magnesium Oxychloride and Oxysulfate Cements:

Committee C-2 on Magnesium Oxychloride and Oxysulfate Cements recommended a number of specifications. The first of these, proposed Tentative Specifications for Oxychloride Magnesia (C 275-51 T) which was approved, covers the chemical and physical requirements for oxychloride magnesia used in magnesium oxychloride cements. Oxychloride magnesia is essentially magnesium oxide produced by the calcination of natural magnesite or other magnesium compounds, and which will react with the chloride or sulfate content of solutions of magnesium chloride or magnesium sulfate of suitable concentrations to form a plastic cement capable of setting and binding inert organic and inorganic fillers and aggregates into a hard, strong, and durable mass.

The second approval pertains to tentative Specifications for Magnesium Chloride (C 276-51 T) and cover specifications for magnesium chloride to be used for oxychloride cement when analyzed by methods of analysis set forth in the Tentative Method for Analysis of Magnesium Chloride (C 245-50 T). If a solution of magnesium chloride should be supplied, the proportions of calcium and alkali chlorides to magnesium chloride shall not exceed those permitted for a dry form of magnesium chloride.

In a third recommendation Tentative Specifications for Magnesium Sulfate (Epsom Salts, Technical Grade) (277-51 T) have also been approved. These Specifications cover magnesium sulfate to be used for oxychloride cement when analyzed by methods of analysis set forth in the Tentative Method for Analysis of Magnesium Sulfate (C 2244-50 T).

Cement:

The Administrative Committee on Standards also approved quite a number of revisions recommended by Committee C-1 on Cement. These are as follows:

- Methods of Chemical Analysis of Portland Cement (C 114-47)
- Tentative Methods of Chemical Analysis of Portland Cement (C 114-48 T)
- Tentative Specification for Air-Entraining Additions for Use in the Manufacture of Air-Entraining Portland Cement (C 226-50 T)
- Specification for Portland Cement (C 150-49) and of Tentative Specifications for Air-Entraining Portland Cement (C 175-50 T)
- Method of Test for Autoclave Expansion of Portland Cement (C 151-49)
- Tentative Definition of the Term Addition as Applied to Hydraulic Cement C 219-48 T)

Clag Pipe:

Recommendations of Committee C-4 on the proposed Tentative Specification for Extra-Strength Ceramic Glazed Clay Pipe (C 278-51 T) has been accepted. These clay pipes are intended to be used for the conveyance of sewage, industrial wastes, and storm water and other liquids. The clay pipes are manufactured from surface clay, fire clay, shale, or a combination of these materials. In connection with the above proposal, the revision and reversion to tentative of the Recommended Practice for Laying Sewer Pipe (C 12-19) has also been accepted. This new recommended practice modifies and brings up-to-date the method of pipe laying as well as the nomenclature pertaining thereto.

Masonry Units:

A proposed Tentative Specification for Chemical Resistant Masonry Units (C 279-51 T) as recommended by Committee C-15 has been accepted. These specifications cover machine-made, uncored, kiln-fired brick made predominantly from clay or shale or mixtures thereof and suitable for use in masonry construction for contact with chemicals. These units are designed primarily for use in the chemical or allied industries and are normally used with chemical-resistant mortars.

Porcelain Enamel:

Committee C-22 on Porcelain Enamels recommendations on the establishment of new tentatives have been approved. These are Tentative Definitions of Terms Relating to Porcelain Enamel (C 286-51 T) These definitions are identical with those which have been accepted by the Committee on Nomenclature and the Enamel Division of The American Ceramic Society. Committee C-22 has felt that these definitions constitute a desirable part of the literature of ASTM, especially since they include numerous terms which are common to the porcelain enamel industry.

In line with the above, Tentative Methods of Test for Sieve Analysis of Wet Milled and Dry Milled Porcelain Enamel (C 285-51 T) has been accepted. Proper sieve analysis is a very important operation in the preparation of both wet processed and dry processed porcelain enamel for application. These methods of test cover the procedures for determining the fineness of frit in wet or dry milled porcelain and other ceramic coatings for metals by means of the No. 200 (74 μ) or No. 325 (44 μ) sieves.

A Tentative Method of Test for the Resistance of Porcelain Enameled Utensils to boiling Acid (C 283-51 T) has been approved. This tentative is a standard test of the Enameled Utensil Manufacturers Council and the method is widely used in the industry for determining the resistance of enamel surfaces to boiling fruit acids.

Also accepted was Tentative Method of Test for Impact Resistance of Porcelain Enameled Utensils (C 284 – 51 T). This method is used widely throughout the industry for determining the impact resistance of utensils and similar shaped objects. Together with the above, it has been recommended that Tentative Method of Test for Acid Resistance of Porcelain enamels (C 282 – 51 T) (Room Temperature Test) be accepted. These test methods have been for many years standards of the Porcelain Enamel Institute and the American Chemical Society.

Miscellaneous Materials

Road and Paving Materials:

Committee D-4 on Road and Paving Materials recommended a number of tentative specifications. Tentative Method of Test for Specific Gravity of Compressed Bituminous Mixtures (D 1188 – 51 T) has been accepted since ASTM at the present time has no tentative or standard method for determining specific gravity for compressed bituminous mixtures comprising granular materials which contain air voids. Specific gravity is an important property of bituminous pavements and of laboratory specimens used for study of bituminous mixtures.

The new Tentative Specifications for Crushed Stone, Crushed Slag, and Gravel for Bituminous Concrete Base and Surface Courses of Pavements (D 692 – 51 T) has been established in order to cover the quality and grading of crushed stone, crushed slag, and crushed gravel suitable for use as coarse aggregates in bituminous concrete for base and surface of pavements. In connection with the above tentative specifications, the withdrawal of Standard Specifications for Crushed Stone, Crushed Slag, and Gravel for Bituminous Concrete Base and Surface Courses of Pavements (D 692 – 49) have been approved.

Tentative Specifications for Fine Aggregate for Sheet Asphalt and Bituminous Concrete Pavements (D 1073 – 49 T) have been accepted providing a new section on Soundness. The fine aggregate when subjected to 5 cycles of the soundness test shall have a weight loss of not more than 15 per cent when sodium sulfate is used or 20 per cent when magnesium sulfate is used.

Revision of Standard Specifications for Granite Block for Pavements (D 59 – 39) provides for an alternate method of specifying and determining the quality of the granite from which the blocks are made. The alternate method is in common use in testing laboratories for highway materials, whereas the determination of French coefficient of wear now required by the standard specification is rarely made.

Shipping Containers:

Committee D-10 on Shipping Containers had its proposed Tentative Methods of Test for Pallets (D 1185 – 51 T) approved. Until now no tests for pallets existed. The tests include methods for determination of the static load capacity of pallets, shock load capacity of pallets, drop test, inclined impact test, and vibration test.

Industrial Water:

Committee D-19 on Industrial Water had a number of proposed tentative specifications and one proposed revision of tentative method approved. Tentative Specification for Equipment for Sampling Industrial Water and Steam (D 1192 – 51 T) presents the apparatus necessary for conditioning water samples, that is, sampling lines, cooling coils, etc. This information is at present scattered in other methods and in its new form provided the reader with all factors necessary for the design and construction of the specific apparatus.

Tentative Specification for Reagent Water (D 1193 – 51 T) has been accepted so that the term "Reagent Water" be limited to water solely for laboratory use. Two grades of water are specified: referee reagent and nonreferee reagent water. Reagent water may be prepared by distillation, by condensation of commercial steam, or by use of a suitable demineralization process.

The Revision of Tentative Method for Sampling Boiler Water from Stationary Boilers (D 860 – 48 T) was approved and covers the basic requirements for the sampling of boiler water from steam generators for analysis of boiler water constituents and control and for special investigations.

NOTES ON PUBLICATIONS

Report on the Principles Involved in the Determination of Absolute Viscosity

A VERY important part of the 1951 annual report of Committee E-1 on Methods of Testing was the appended Report on the Principles Involved in the Determination of Absolute Viscosity compiled by the Task Group on Methods and Apparatus for Absolute Viscosity Measurements of Subcommittee 9 on Rheological Measurements. In compiling this information, the task group intended to encourage the recognition and practice of the use of instruments yielding results in standardized units having true physical dimensions that will convey the same meaning in all laboratories.

The report analyzes instruments in which the fluid motion is interpreted in terms of fundamental viscometric units "dyne second per square centimeter or poises." But every instrument which would fit this description is not dealt with, only those which have found wide acceptance in industry. Accessibility of the methods to all industries interested in the phenomena of fluid flow has been given consideration in the preparation of this report.

Absolute viscosity may be determined by two types of instruments, absolute viscometers and relative viscometers. The absolute type viscometers allow the determination of viscosity without the knowledge of the viscosity of other fluids, while the relative type viscometers are useful only when "standard" materials of known viscosity are available for calibration purposes. No comparison between the two types of viscometers has been attempted.

The number of fluid materials involved in the measurements of viscosity have viscosities ranging from a small fraction of a poise up to billions of poises. This variation in viscosity is tied in with the kind of flow the fluid exhibits. The viscosities of some liquids do not change with changing rates of flow, others become more viscous as flow increases, still others become more fluid with increasing velocity of flow. Materials behaving in any of the above ways may or may not flow upon application of forces below certain limits. These ranges of degree and kind have led to the development of numerous ways of observing the behavior of fluids in motion.

Viscometers in this report have been classified according to the measurements employed and may be distinguished by: (1) the rate of fluid flow in tubes, (2) the rate of motion of solids through subject media, (3) the rate of rotation of solids in the media, (4) the distortion of solids by forces transmitted through the media from other solids in motion, (5) the damping effect of a medium on a solid vibrating in it, and (6) the distortion of media under compression. The analysis and interpretation of the experimental results obtained with viscometers in these six classes differ appreciably and have been outlined briefly in the discussion of the individual instruments. Mathematical details have been omitted. These details can be found by referring to the numerous references cited.

Symposium on Triaxial Shear Testing

THE Symposium on Triaxial Testing of Soils and Bituminous Mixtures has been released for press. Because of the close similarity of problems involved in testing both soils and bituminous paving materials under triaxial loading, several papers presented in this symposium cover both the use of the triaxial test in the design of soil subgrades and bituminous mixes for highway work.

Three interesting papers on the applications of the triaxial test to bituminous mixtures, presented at the Society's First Pacific Area National Meeting Oct. 10, 1949, are included. These papers were prepared by members of subcommittee B-2 of ASTM Committee D-4 on Road and Paving Materials. Subcommittee R-5C on Methods of Testing Soils Under Triaxial Loading of ASTM Committee D-18 on Soils for Engineering Purposes sponsored the Symposium on Testing Soils Under Triaxial Loading at the 1950 Annual Meeting. Other papers which brought out some of the current thinking on this subject are also included in this compilation.

Within the fields covered in this publication triaxial tests are applied to materials belonging to the class of plastics rather than that of rigid-elastic materials. A simple definition of a "plastic," in this sense, is a material which under stress flows rather than ruptures and which has either no yield point at all, or a very low one in relation to its total resistance to shear. The word "triaxial" is applied to a form of mechanical test under which a load is applied axially to a cylindrical specimen, while a supporting pressure is maintained against its sides by water, air, or other means.

Copies of the 310-compilation can be obtained through ASTM, 1916 Race Street, Philadelphia 3, Pa., at a price of $3.50 for nonmembers and $2.60 for members.

1951 Supplements to the Book of Standards

WORK has already been started to prepare the 1950 Supplements to the current 1949 Book of ASTM Standards, looking toward the publication of these Supplements, to come out at varying intervals over the period November 30–February 1. There will be a Supplement to *each* of the six Parts, bound in heavy paper cover.

Exactly when each Supplement will appear has not been determined, but it is probable that those for Parts 2, 3, and 5 covering Non-Ferrous Materials; Cement, Concrete, Ceramics, Thermal Insulation, etc., and Textiles, Soap, Fuels, Petroleum Aromatic Hydrocarbons, and Water, respectively, may appear first.

Each *member* will receive automatically the Supplements matching the Parts of the Book of ASTM Standards he has already received, these instructions being on file at Headquarters. All *purchasers* of the Book of Standards, including the many members who buy extra Parts, will receive in the next few weeks an order form by which they can purchase the Supplements to match the Books of Standards they have bought.

With the Supplements will be stickers noting changes in standards so that members can affix these at the designated pages in the big books and thus aid in keeping these up to date. Obviously the respective Supplements should be placed right next to the Parts of the big book so that the latest standards can be referred to conveniently. The Supplements will contain not only revised material but also many new specifications and tests.

Soon after the last Supplement is issued there will be printed another Index to Standards which will give the latest references to the appropriate source where the specifications can be found. This is sent to all members and each purchaser of the Book.

Extra additional copies of the Supplements can be procured through ASTM Headquarters at $21 for all six parts or at $3.50 for single part to non-members, or $16.50 for all parts or at $2.75 for one part to members.

1951 Year Book Published

BY THE time this BULLETIN goes to press, the 1951 Year Book will have been distributed to those members who have requested a copy. This 600-page publication gives much information of service to the members. About 150 pages are devoted to an alphabetic list of the membership, with the addresses and titles of the individual members and the company representatives shown. One of the most interesting and most useful portions (over 300 pages) of the Year Book is the committee personnel section. This section lists all technical and other committees and their officers and gives the complete personnel of the main committees and subgroups. Anyone not cognizant of the work of the Society would no doubt be amazed at the large number of committees and at the number of men and organizations serving on them.

Other portions of the Year Book are devoted to the By-laws and Charter, and various sets of regulations, lists of winners of awards, information on administrative committees and District Councils. And there are bound in the book ASTM membership application blanks so that members will have these available when a new membership is in the offing.

This book is distributed to members on request and many have asked that their name be included in the permanent mailing list. Each new member receives a copy and has the opportunity of asking that his name be added to the permanent mailing list.

The Year Book is not available for general distribution; it is published only for distribution to the members for their use in connection with the activities of the Society.

Textile Compilation Now Available

CONTAINING all the standards on textile materials and related information on photomicrographs of fibers a yarn number conversion table, humidity table, committee data, and the new 612-page compilation of ASTM Standards on Textile Materials covers most of the widely used products of this industry.

This current revision of this compilation continues to provide testing methods, acceptable tolerances, and specification requirements on quality. This 1951 edition, it is hoped, will provide conveniently all the data and information believed to be of importance to those who deal with textile materials.

An important part of the compilation is the glossary of textile terms and terms related to hand of fabrics.

Many specifications are included on such things as Specification and Tests for Asbestos Yarns, Specifications for Woven Cotton Tapes for Electrical Purposes, Tests for Felt, Test for Apparent Fluidity of Dispersions of Cellulose Fibers, Tests for Single Kraft Yarn, Test for Stretch of Hosiery, etc.

The compilation developed by Committee D-13 contains altogether 52 standards and 34 tentatives with Test for Resistance to Abrasion of Textile Fabrics being a new tentative adopted. The compilation sells for $5 to nonmembers and $3.75 to members.

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OCTOBER 1951

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NINETEEN-SIXTEEN
RACE STREET
PHILADELPHIA 3, PENNA.

H. L. Maxwell Elected ASTM Vice-President

H. L. MAXWELL, Supervisor of Mechanical Engineers Consultants, E. I. du Pont de Nemours & Co., Inc., has been elected by the Board of Directors to fill the vacancy of Vice-President which existed in the Board. Because of the inability due to poor health of the late F. E. Richart to assume the Presidency of the Society, the then Junior Vice-President, T. S. Fuller, was nominated and elected President, and in June the members elected Dr. L. C. Beard, Jr., Socony-Vacuum Oil Co., Inc., as Vice-President for a term of two years. Dr. Maxwell will serve as Vice-President through June, 1952.

Active in the Society for many years, he completed a three-year term as a Director in 1950.

Dr. Maxwell received his Ph.D. in Chemical Engineering and Metallurgy in 1924 from Iowa State College, following which he was instructor in Industrial Chemistry there for two years and Associate Professor of Chemical Engineering, Purdue University, 1926–1930. A leading authority on materials, particularly in the field of metallurgy, Dr. Maxwell was employed as Metallurgist for the Du Pont Co., Ammonia Department 1930–1933, then placed in charge of Metallurgy, Engineering Department for 13 years.

H. L. Maxwell

The 1951 Nominating Committee

IN ACCORDANCE with the By-laws providing that the Board of Directors shall select a nominating committee for officers, the Board has considered the report of the tellers—E. E. Eakins, Laminar Calcium Corp., and J. B. Abele, Philadelphia Electric Co.—on the recommendation of members for appointees on the nominating committee and alternates, and has appointed the following:

Nominating Committee

Members

C. E. Loos, United States Steel Co.
W. H. Klein, Lawrence Portland Cement Co.
W. T. Pearce, Consultant
A. T. Goldbeck, National Crushed Stone Assn., Inc.
A. E. Miller, Sinclair Refining Co.
Jerome Strauss, Vanadium Corporation of America

Respective Alternates

T. G. Stitt, Pittsburgh Steel Co.
R. R. Litehiser, Ohio State Highway Testing and Research Laboratory
C. H. Rose, National Lead Co.
H. C. Plummer, Structural Clay Products Inst.
J. C. Geniesse, Atlantic Refining Co.
Hyman Bornstein, Deere and Co.

Serving on the 1952 Nominating Committee as *ex-officio* members are the three immediate past-presidents: R. L. Templin, J. G. Morrow, and L. J. Markwardt. The committee will meet sometime in March and nominate for each office—president, vice-president, and five members of the Board of Directors. The selection by the Nominating Committee will be announced to the members in the ASTM BULLETIN prior to transmission of official ballots.

Eighth ASTM Photographic Exhibit, June 23–27, New York

THE Photographic Exhibits and Competition which have been staged during years when there has been an apparatus exhibit have come to be looked on as an interesting and worthwhile adjunct to the Annual Meeting. The Eighth Exhibit will be held during the Society's Fiftieth Anniversary Meeting at the Hotel Statler in New York during the week of June 23–27.

A committee is being organized under the chairmanship of Myron Park Davis to plan and supervise the arrangements. Among the important divisions will be a section on photomicrography sponsored by Committee E-4 on Metallography. This group is planning to give even more emphasis to its section than in previous years. Considering that there have been many interesting exhibits in this field, members can look forward to spending some time profitably at the 1952 Exhibit.

Since the committee will probably establish another section dealing with general photography, scenic and otherwise, members may wish to begin earmarking prints of this kind. The basic theme of course will be in line with the Society's technical activities, and photographs of testing equipment, evaluation of materials, scientific personnel, and the like are welcome. Further details will be given later, probably in the form of an entry blank.—*Photographers start earmarking your prints now.*

Offers of Papers for 1952

PLANS are already pretty well advanced for the technical program for the 1952 Annual Meeting which will commemorate the Fiftieth Anniversary of the Society. This applies particularly with respect to a number of symposiums that are being developed. There will, however, still be a place for a limited number of independent contributions, and we are including our usual announcement to the effect that offer forms are available on request to all those who may wish to submit an offer of a paper for the Annual Meeting.

The general keynote for the meeting is "Testing," and any papers that are submitted should be appropriate to this general theme. There is also given below a list of the various symposiums that are now in prospect and in case any author has a paper that he believes would be particularly pertinent in connection with any of these symposiums,

we should be glad to bring this to the attention of the symposium committee in question.

- Symposium on Tin
- Symposium on Fretting Corrosion
- Symposium on Adhesives
- Symposium on Direct Shear Tests of Soil
- Symposium on Exchange Phenomena in Soils
- Round Table Discussion on Continuous Analysis of Water
- Symposium on Plastics
- Symposium on Conditioning and Weathering
- Symposium on Methods for Determining Elastic Constants
- Symposium on Light Microscopy
- Sessions on Fatigue

ASTM 50 Years Ago

The Anniversary we will be celebrating next year is the Fiftieth Anniversary of our official *incorporation. Actually in 1902 the Society had already been in active existence for three years as the American Section of the International Association for Testing Materials. During the Society's Third Annual Meeting, Oct. 25, 26, and 27, 1900, the chairman, Prof. Mansfield Merriman, gives a hint of things to come in his address in which he expresses the dissatisfaction the American Section felt toward the parent body:*

"It may here be plainly stated that the policy of the International Association in regard to publications is not satisfactory to many American members. The proceedings of the Council meetings are not published, no financial statements are given out, and practically nothing is known of the work of the technical committees. This is the more remarkable because the Journal "Baumaterialienkunde" has been designated as the official organ of the Association and receives compensation therefor.

"Besides the eight pages in "Baumaterialienkunde" there have been issued by the Association during the past year two circulars relating to the Paris Congress, and a pamphlet containing an International List of Members and Technical Committees. This list was closed on June 30, but the copies of the same forwarded to this country did not reach us until January, by which time our membership had increased so that the number of copies was not sufficient to supply all the American members. In addition to the above I have to acknowledge the receipt on July 27, 1900, of a typewritten copy of the minutes of the Council meeting held ten months previously, namely, on September 25 and 26, 1899.

"Attention may also properly be called to the fact that no statements regarding the expenditures of the Association have ever been made, as far as I am able to learn. As the American Section has regularly transmitted to the International Council $1.50 per year for each of its members, it would seem that such statements are due us. In my opinion, it becomes a question to be carefully considered as to whether this state of affairs ought to be continued indefinitely. After the experience of over two years in conducting business with the International Authorities, I have been forced to the conclusion that a reorganization is necessary in order to enable it to effectively conduct its affairs and successfully carry on its scientific work."

ASTM 25 Years Ago

1. The Twenty-Ninth Annual Meeting was held at Chalfonte-Haddon Hall, Atlantic City, N. J. The total attendance was 1144, of whom 792 were members, 113 guests and 239 ladies.

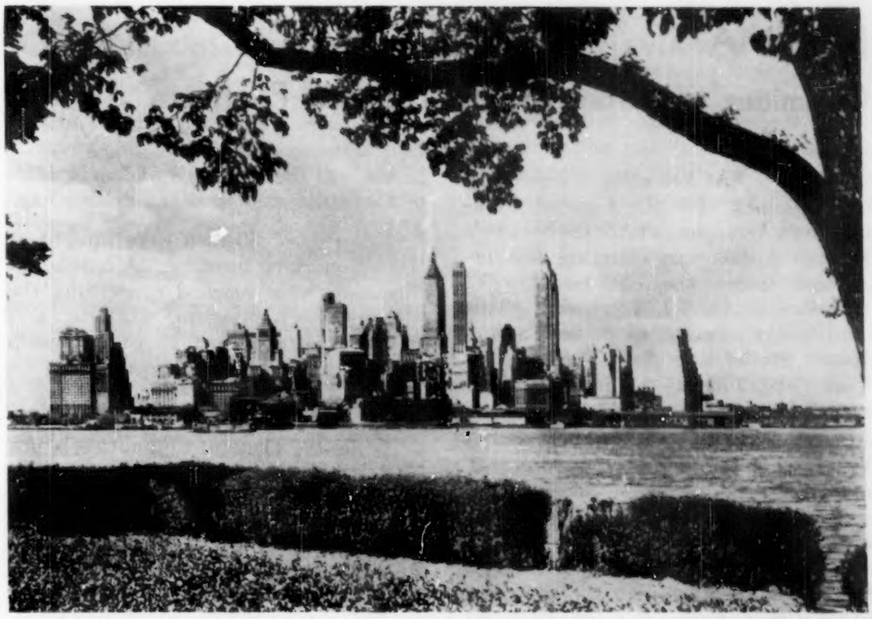
2. The 1926 Year Book contained about 375 *pages.*

3. The membership in 1926 was 4044 and was steadily growing.

4. The Proceedings *for 1926 comprised over 1800 pages—the largest in the Society's history with the exception of the* Proceedings *for 1924.*

5. Arthur N. Talbot, Professor in Charge of Theoretical and Applied Mechanics, University of Illinois, was the first Edgar Marburg Lecturer. Professor Talbot was then an honorary member and has been a Past-President of the Society. His talk was on "Research and Reinforced Concrete as an Engineering Material," a subject which would find wide acceptance even today.

6. With the Apr. 30, 1926, issue the BULLETIN *was enlarged to include pages available for advertising, therefore placing the* BULLETIN *substantially upon a self-sustaining basis and making it possible eventually to increase the* BULLETIN *service. The policy had been adopted to receive only the following classes of advertising: (1) that of manufacturers and suppliers of testing machines, testing apparatus and similar equipment, and of testing laboratories; (2) that of book dealers and publishers of technical books, especially those relating to materials; and (3) professional cards of consulting engineers, metallurgists, chemists, testing engineers and testing laboratories.*



A Few Facts About Lower Manhattan

DISCOVERED by Henry Hudson, Sept. 11, 1609, Manhattan Island was inhabited by white men for the first time in 1613. In 1626 the island was purchased by the Dutch through Peter Minuit from the Indians for trinkets valued about $24. Fort Amsterdam was built on the site of the present customhouse in 1635. The customhouse itself was built in 1907 of Maine granite at a cost of $5,130,000. Forty-four Corinthian columns surround the building. Twelve statues carved from Tennessee marble represent the seafaring powers, which have taken part in world commerce. City Hall is the third building housing city hall since the city was first established as New Amsterdam. In the Governor's Room are the desks of the first three Presidents of the United States; also portraits of outstanding personalities in the nation's history. From the Battery Park adjacent to the customhouse one can see the Statue of Liberty, Ellis Island or, by reversing one's position and looking uptown, the business sections of Wall Street and finally City Hall. The Statue of Liberty, located on Bedloe's Island, New York Harbor, is about 1½ miles south of Battery Park. Presented to the United States by France on July 4, 1884, designed and constructed by Bartholdi, the statue is 152 ft high and stands on a pedestal of almost the same height. Ellis Island is north of the Statue of Liberty also in the New York Harbor. Here the U. S. Immigration Service detains immigrants while examining their qualification for legal entry into this country.

Wall Street, as the world renowned financial center, is the most famous quarter of a mile in the world. In 1650 a wall was built from river to river to protect a small colony living south of this street from attacks by Indians. Later it was considered the finest residential section of the period.

Fiftieth Anniversary Meeting

Committee on Arrangements; Technical Program

AT A meeting in New York on September 10, the General Committee on Arrangements for the Society's Fiftieth Anniversary Meeting was organized under the chairmanship of Past-President J. R. Townsend. This anniversary meeting, to be held at the Hotels Statler and New Yorker, New York City, June 23–27, incl., will also include the Tenth Exhibit of Testing Apparatus and Laboratory Supplies and the Eighth Photographic Exhibit. A number of other features for the meeting will be developed by the General Committee.

A list of the officers of the General Committee together with the chairmen of the subcommittees thus far appointed follows:

Officers

F. M. Farmer, *Honorary Chairman*, President, Electrical Testing Laboratories, Inc.

J. R. Townsend, *Chairman*, Materials Engineer, Bell Telephone Laboratories, Inc.

L. T. Work, *Vice-Chairman*, Consulting Engineer

H. C. R. Carlson, *Vice-Chairman*, Design Consultant, The Carlson Co.

G. O. Hiers, *Secretary*, Metallurgist, National Lead Co.

W. B. Anderson, *Assistant Secretary*, Technical Executive, Titanium Pigment Corp.

Jerome Strause, *Treasurer*, Vanadium Corp. of America

Subcommittee Chairmen

Dinner—H. C. R. Carlson, Design Consultant, The Carlson Co.

Entertainment—Sam Tour, Chairman of the Board, Sam Tour and Co., Inc.

Information Center—E. P. Pitman, Engineer of Inspection, The Port of New York Authority

Non-Technical Program—L. C. Beard, Jr., Assistant Director, Socony-Vacuum Laboratories, Socony-Vacuum Oil co.

Laboratory and Plant Visits—L. T. Work, Consulting Engineer

Promotion and Publicity—Ephraim Freedman, Director, Macy Bureau of Standards, R. H. Macy and Co., Inc.

Finance—K. G. Mackenzie, Assistant to Vice-President, The Texas Company

Apparatus Exhibit—Gordon Thompson, Chief Engineer, Electrical Testing Laboratories, Inc.

Photographic Exhibit—Myron Park Davis, New York and New Jersey Lubricant Co.

Technical Program Liaison—George R. Gohn, Member of Technical Staff, Bell Telephone Laboratories, Inc. and member of the Society's Administrative Committee on Papers and Publications

Upwards of 50 men were present at the all-morning meeting. A number of decisions were reached concerning the non-technical program, exhibits, and related matters which as they develop will be announced to the members.

Technical Program:

While the General Committee is not responsible for the development of the technical program, it is following this closely through G. R. Gohn, Bell Telephone Laboratories, Inc., who as a member of the ASTM Administrative Committee on Papers and Publications heads a small group in the Administrative Committee to coordinate the technical features. At the meeting Mr. Gohn outlined a number of symposiums which are under development for the Annual Meeting. As noted below, these cover a wide variety of subjects and together expect to aggregate about 20 distinct sessions.

Adding to these symposium sessions others which will include individual technical papers and committee reports there are expected to be a total of 35 to 38 sessions, by far the largest number ever scheduled for an Annual Meeting.

A tentative list of the Symposiums which are in the course of development for the meeting is as follows:

Fretting Corrosion
Adhesives
Direct Shear Tests of Soil
Exchange Phenomena in Soils
Continuous Analysis of Water
Plastics
Conditioning and Weathering
Methods for Determining Elastic Constant
Light Microscopy
Fatigue
Effect of Temperature
Tin

Most of these symposiums are being developed by technical committees of the Society. Further information will be published soon.

All Items on Standards Ballot Approved

THE canvass of the results of the 1951 letter ballot shows that the membership of the Society has approved all of the items listed on the ballot. The list included 67 revisions of existing standards, and 73 adoptions of tentatives as standards. In addition there was accepted a proposed revision of the By-laws on the nomination for honorary membership. Details concerning the actions were given in the Summary of Proceedings of the Fifty-Fourth Annual Meeting, which was mailed to all members in September, together with the letter ballots. The details will also be published in the 1951 Supplements to the 1949 Book of ASTM Standards which are now being prepared.

Schedule of ASTM Meetings

DATE	GROUP	PLACE
October 22	Joint Committee on Chemical Analysis by X-ray Diffraction Methods	Chicago, Ill.
October 23	Pittsburgh District	Pittsburgh, Pa.
October 24	Western New York-Ontario District	Buffalo, N. Y.
October 24–26	Committee C-1 on Cement, and Committee C-9 on Concrete	Lafayette, Ind.
October 25–26	Committee D-15 on Engine Anti-Freezes	Atlantic City, N. J.
October 26	New York District	New York, N. Y.
October 31	Northern California District	San Francisco, Calif.
November 1	St. Louis District	St. Louis, Mo.
November 1–2	Committee B-4 on Electrical Heating, Resistance, and Related Alloys	Headquarters, Phila., Pa.
November 2	Philadelphia District	Allentown, Pa.
November 2	Committee C-18 on Natural Building Stones	Washington, D. C.
November 7–9	Committee B-8 on Electrodeposited Metallic Coatings	Headquarters, Phila., Pa.
November 8	Southern California District	Los Angeles, Calif.
November 13–15	Committee D-20 on Plastics	Niagara Falls, Ont.
November 14–16	Committee D-9 on Electrical Insulating Materials	Niagara Falls, Ont.
November 19	Chicago District	Chicago, Ill.

Fatigue Loss and Gain by Electroplating

The always tempting idea of building up worn and undersized machine elements by electrodeposits is discussed in detail in an article "Fatigue Loss and Gain by Electroplating", by J. O. Almen, Research Laboratories Division, General Motors Corp., appearing in the June, 1951, issue of *Product Engineering*. In the article the author presents data showing the reason for the damage, and its extent that is caused by electrodeposited metals when plated by the methods now in common use, processes whereby advantages of rebuilding by electroplating can be retained without loss of fatigue strength, and suggested developments in electroplating processes, whereby electrodeposited coatings may possibly be made as effective as shot peening in increasing fatigue strength of plated machined parts.

To explain the deleterious effect of the electrodeposit of metal on the fatigue strength of steel it is shown that the deposit metal is residually stressed in tension, from which it necessarily follows that the base metal is residually stressed in compression to maintain equilibrium conditions. When a crack forms in a strongly adhering deposit, the residual tensile stress is locally transferred to the base metal, thereby reducing the fatigue strength of the base metal. A further loss results because the crack constitutes a notch, which is a stress raiser just like a notch of similar depth and sharpness in the surface of the base metal.

Measurements of Residual Stress:

Observations indicating the presence of residual stresses in electrodeposited metals were reported as early as 1860, but it was not until 1877 that the first measurements of their magnitudes were made. The form of measurement consisted of coating thermometer bulbs with certain electrodeposited metals causing the mercury to rise in the stem indicating that the deposited metal was residually stressed in tension. Through the changes in the height of the mercury column, it was calculated that nickel could develop a pressure of 43,000 psi, iron 40,500 psi, and silver 149,000 psi. Residual stresses in plated nickel were more accurately measured by varnishing on one side a thin steel rule 102 mm long, 12 mm wide, and 0.32 mm thick and electroplating with nickel on the other side. In response to the residual tensile stress in the nickel layers, the plated rule bent concave to the extent of 3 to 4 mm on the plated side. Measurements of the nickel thickness and the radius of curvature of the plated specimen provided data from which the residual stress could be calculated. Altering of the magnitude of the residual tensile stress was obtained by variations in temperature of the bath and the plating current. The damage from nickel deposited in the usual manner was reduced from 28 to approximately 7.5 per cent when the steel specimen was given a coat of electroplated lead before the nickel was applied. The ductile layer of lead presumably permitted relaxation of the residual tensile stress in the nickel layer, and any remaining stress was presumably prevented from reaching the underlying steel when cracks developed in the nickel coat.

Cracks in Chromium Plate:

Extreme difficulty has been experienced in measuring the residual stresses in electrodeposited chromium. Within the range of normal current density and bath temperature the tensile stresses are so great that the chromium deposits are almost invariably fractured during the plating operation. Residual tensile stresses in chromium deposits in the normal plating range were found to reach 60,000 psi.

The fatigue endurance limits of both normalized and hardened steels were found to be reduced by chromium plating, the loss being greater for hardened steel. The endurance limits for steel of a given hardness decreased with increased plating bath temperature. Baking the plated specimen at temperatures up to 660 F, for the purpose of removing any effects of hydrogen, further reduced their fatigue strength. When the baking temperature was increased to 825 F, the fatigue strength was increased but not sufficiently to restore the endurance limit to that of the unplated hardened steel specimens. Damaging effects of chromium on the fatigue strength of the plated steels are attributed to residual tensile stresses in the deposited chromium. The stresses are shown to be increased by low temperature baking, but when baked at 750 to 825 F they are partly relieved.

Surface Vulnerability and Applied Loads:

Surface residual compressive stresses induced by such processes as shot peening, superficial rolling, nitriding, and carburizing increase the fatigue strength of the treated specimens. Conversely, surface residual tensile stresses resulting, under certain conditions from such processes as grinding, straightening, induction, and flame hardening decrease fatigue strength.

These effects have been shown to result from the fact that all surfaces regardless of uniformity of section and perfection of finish, are weaker in fatigue than sound subsurface metal and that fatigue failures can result only from tensile stresses. It follows that the tensile stresses in the extra vulnerable surfaces from externally applied loads are reduced in magnitude by surface residual compressive stresses and the fatigue strength of the specimen is thereby increased. Surface residual tensile stresses augment applied tensile stresses and thereby decrease the fatigue strength of the specimen.

It is to be expected, therefore, that electrodeposited metals are harmful to fatigue strength in proportion to the magnitudes of the residual tensile stresses, and are beneficial in proportion to the magnitudes of the residual compressive stresses. Such proportionality is an oversimplification because other factors, among which are adhesion, yield strength, ductility, and the manner in which the tests are conducted, alter the effective increase or decrease in the applied tensile stresses.

Fatigue tests conducted show that the damage caused by electrodeposited nickel decreased from 28 to 7 per cent when the residual tensile stress was reduced from 26,000 psi to 5000 to 8000 psi. They also show that when the residual stress in the plated layer was changed from tension to compression, as occurred in zinc deposits, the fatigue strength of the coated steel specimens was greater than the unplated specimens.

Residual Stress Varies Greatly:

As a result of variations in Watts nickel bath composition, the residual stress is seen to range from a minimum of 5900 psi tension to a maximum of 43,000 psi tension. Significant stress changes also occur with variations in bath temperature and with the thickness of the plated layers. Note the great increase in residual stress when the bath was contaminated with iron.

The residual stresses in nickel deposited on steel from the proprietary baths, range from 70,000 psi tension to 9700 psi compression for a total variation of nearly 80,000 psi. As in the Watts bath, significant stress changes occurred with variations in bath temperatures. Nickel deposited in a state of low tensile stress or in residual compression did not crack in the salt spray test as did specimens in which the residual tensile stress was relatively great. The tests were not, however, sufficiently

numerous or varied to determine whether corrosion resistance increases with the magnitude of the residual compressive stress as was expected. This probability remains to be explored.

Controlled Stress in Nickel Deposits:

Two groups of specimens for fatigue tests were prepared so that the nickel deposited on one group would be residually stressed in tension and on the second group would be residually stressed in compression. The procedure that was selected for plating the first group of specimens developed residual tensile stress of 25,000 psi and the process used for the second group developed 6000 psi residual compressive stress. The plated specimens were fatigue tested in comparison with noncoated, fully polished specimens of the same base steel. The endurance limit of the polished base steel was found to be 45,000 psi which dropped to 29,000 psi when plated with the 25,000 psi tension stressed nickel. The specimens plated with nickel stressed to 6000 psi compression actually indicated a gain in strength. The indicated gain, however, is well within the range of experimental error and it should be assumed that these compressively stressed nickel-plated specimens are approximately equal to the polished base steel. The differences shown between tensile and compressive residual stress are sufficiently great to justify the conclusion that fatigue strength of nickel-plated specimens is directly affected by the state of residual stress in deposited nickel.

Since under reversed loading, much of the residual compressive stress may be lost by compressive yielding, it is desirable to coat the surface of the base metal with a deposit having a high elastic limit, as well as good adhesion and high residual compressive stress. A coat that possesses these qualities need not have much ductility. Effectiveness of the residual compressive stress in plated metal is lost unless the bond to the base metal is strong enough to support the stress at the junction of the two metals.

If chromium can be plated in a state of high residual compression together with high bond strength, it will be superior to nickel for rebuilding and fatigue strengthening purposes.

Mechanical Prestressing Effective:

Although electrodeposited coatings that are residually stressed in compression are more desirable for structural purposes, including protection against corrosion, it is possible to avoid much of the loss of fatigue strength resulting from coatings that are residually stressed in tension. Since fatigue failures occur only from tensile stresses, the extension of cracks formed in the plated metal into the base metal can be prevented by inducing residual compressive stress in the surface of the base before plating. Prestressing of the base metal can be accomplished by shot peening, superficial rolling, and other mechanical and thermal treatments. It has been estimated that the fatigue strength of specimens plated after peening is greater than that of the fully polished base steel but not as great as that of the peened but uncoated base metal. Prestressing is seen to have increased the fatigue strength of chromium-plated steel 35 per cent.

If nickel is used in place of chromium and the specimen prestressed by shot peening the fatigue strength of the nickel-plated specimen is more than doubled. In many applications it will be found desirable to prestress by superficial rolling rather than by shot peening. Rolling can develop residual compressive stress of exceptional magnitude and surface roughening can be thus avoided.

Laboratory Tests Often Misleading:

Whether prestressing is induced by suitable plating processes or by mechanical operations before or after plating, the effectiveness of the residual stress in increasing fatigue strength cannot be measured by arbitrary repeated loading schedules. Preferred laboratory fatigue specimens apply reversed loads of equal magnitude whether the tests are in bending, torsion, or push-pull. Specimens subjected to reversed stresses lose substantial parts and sometimes all of the compressive residual stress by compressive yielding of the surface or tensile yielding of the core. The result in loss of fatigue strength in as great or greater proportion than the loss of residual compressive stress.

Few machine parts operating in normal service are subjected to reverse loading. The true effectiveness of prestressing treatments applied to machine parts can only be found in actual service use of the treated par tor, less accurately by a laboratory test in which the machine part is subjected to a loading schedule similar to that which occurs in normal service.

Technical Organizations Unite To Combat Corrosion

There is no member of the ASTM that does not have an interest either academically or financially in corrosion control and prevention, whether it be in the service life of plant equipment subjected to corrosive chemical environment or whether it be a personal interest in how long the chromium plating on the bumper of his car may be expected to last.

Because of the interest of our Society members, it has seemed desirable to include in the ASTM Bulletin some mention of the corrosion work of other nationally known groups. One of the best sources of such information is the annual reports submitted to the Inter-Society Corrosion Committee, which has been organized to provide a liaison between the various technical corrosion committees of the National Association of Corrosion Engineers and other national technical societies.

The National Association of Corrosion Engineers is less than 10 years old but already has gained prominence as one of the foremost organizations in this country investigating corrosion phenomena and disseminating information on corrosion protection and control.

The Inter-Society Corrosion Committee is of still more recent origin but its membership is representative of the Government agencies and technical societies of North America interested in corrosion. Such broad representation suggests a successful fulfillment of the objectives of the Inter-Society Corrosion Committee outlined elsewhere in this article.

National Association of Corrosion Engineers

The National Association of Corrosion Engineers was organized in 1943 by a group of men who recognized the need for an organization devoted exclusively to establishment of recommendation of good practices, and formulation of policies for the solution of mutual problems of corrosion control. In less than ten years its membership has passed the 2000 mark and includes members from more than 25 foreign countries.

The purposes of the organization are clearly set forth under Article II of the Articles of Organization, as follows:

(a) To promote the prevention of corrosion, thereby curtailing economic waste and conserving natural resources.

(b) To provide forums and media through which experiences with corrosion and its prevention may be reported, discussed, and published for the common good.

(c) To encourage special study and research to determine the fundamental causes of corrosion, and to develop new or improved techniques for its prevention.
(d) To correlate study and research on corrosion problems among technical associations to reduce duplication and increase efficiency.
(e) To promote standardization of terminology, techniques, equipment, and design in corrosion control.
(f) To contribute to industrial and public safety by promoting the prevention of corrosion as a cause of accidents.
(g) To foster cooperation between individual operators of metallic plant and structures in the joint solution of common corrosion problems.
(h) To invite a wide diversity of membership, thereby insuring reciprocal benefits between industries and governmental groups as well as between individuals and corporations.

The five standing committees are:

Technical Practices Committee
Publication Committee
Regional Management Committee
Policy and Planning Committee
Inter-Society Corrosion Committee

Of the five standing committees, the activities of the Inter-Society Corrosion Committee are probably of greatest interest to the ASTM.

Within the NACE are 18 technical practices committees covering many phases of corrosion. The following list of the committees and their titles indicates the wide range of activities:

TP-1	Corrosion of Oil and Gas Well Equipment
TP-2	Galvanic Anodes for Cathodic Protection
TP-3	Anodes for Use with Impressed Currents
TP-4	Minimum Current Requirements for Cathodic Protection
TP-5	Corrosion Problems Involved in Processing and Handling Chemicals
TP-6	Protective Coatings
TP-7	Materials for Use at High Temperatures
TP-8	Corrosion by Waters
TP-9	Corrosion Inhibitors
TP-10	Corrosion Fatigue
TP-11	Identification of Corrosion Products
TP-12	Effect of Electrical Grounding on Corrosion
TP-13	Annual Losses Due to Corrosion
TP-14	Instruments for Corrosion Measurements
TP-15	Corrosion Control in the Transportation Industries
TP-16	Electrolysis and Corrosion of Cable Sheaths
TP-17	Standardization of Procedures for Measuring Pipe Coating Conductance
TP-18	Internal Corrosion of Facilities for Storage and Transportation of Petroleum

Inter-Society Corrosion Committee

The Inter-Society Corrosion Committee consists of delegates appointed by the technical societies and the Government agencies of North America working in the field of corrosion. The present membership includes:

Alloy Casting Institute
American Association for the Advancement of Science, Gordon Research Conference on Corrosion
American Chemical Society
American Electroplaters Society
American Foundrymen's Society
American Gas Association
American Institute of Chemical Engineers
American Institute of Electrical Engineers
American Pulp and Paper Mill Superintendents Association, Inc.
American Society for Metals
American Society for Testing Materials
American Society of Heating and Ventilating Engineers
American Society of Mechanical Engineers
American Society of Refrigerating Engineers
American Water Works Association
American Welding Society
Association of American Railroads
Chemical Institute of Canada
Electrochemical Society
Federation of Paint & Varnish Production Clubs
National Association of Corrosion Engineers
National Bureau of Standards
National District Heating Association
National Research Council
National Research Council of Canada
Office of Naval Research
Signal Corps Engineering Laboratories
Society of Automotive Engineers
Society of Rheology
Technical Association of the Pulp and Paper Industry

The objectives of the committee have been outlined as follows:

1. To promote cooperation among the various technical societies working in the field of corrosion.
2. To prepare and publish periodically a directory of corrosion workers in the United States.
3. To provide a liaison between the various technical corrosion committees of the NACE and other national technical societies.
4. To act in an advisory capacity to the various technical societies interested in corrosion in an effort to promote progress of all and avoid excessive duplication of effort.
5. To recommend in which society a proposed new activity might best be carried out without, however, attempting to define or limit the field of activity of any society.
6. To stimulate the publication of reliable data on corrosion and to provide publicity for conferences and conventions in this field.

As one means of furthering these objectives, the ISCC each year asks each member organization to report on its current activities in the corrosion field.

For the information of the many members of the ASTM interested in corrosion prevention and control, the various reports covering activities during 1950 and submitted to the Inter-Society Corrosion Committee are summarized below.

American Electroplaters Society:

The Research Committee of the AES reported progress on a number of projects in the past year. These projects included:

(a) Effect of surface finishing of nonferrous base metals on the protective value of plated coatings. Three series of chromium- and nickel-plated brass will be evaluated after atmospheric exposure.
(b) Effect of impurities on plating solutions. These studies indicated that as little as 10 ppm copper can cause 20 per cent loss of salt fog resistance and a 60 per cent loss with nickel plated from a solution containing 50 ppm copper.
(c) Nature of porosity of electrodeposits and its effects indicating that variations in polishing, etching, or coating can affect permeability and corrodibility. Current efforts are toward establishing the mechanism of corrosion toward certain electrodeposits by successive analyses of corrosion products to determine the change of ratio of basis metal and coating metal ions in the products as corrosion progresses.
(d) Relationship between permeability and protective value of electroplated coatings. This study is designed to find a new means, superior to the salt fog test, of determining the protective value of coatings.

American Society for Testing Materials:

A report submitted by the ASTM included work under way or contemplated by:

Committee A-5 on Corrosion of Iron and Steel
Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel, and Related Alloys
Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys
Committee B-4 on Electrical Heating, Resistance, and Related Alloys
Committee B-6 on Die-Cast Metals and Alloys
Committee B-7 on Light Metals and Alloys, Cast and Wrought
Committee C-19 on Structural Sandwich Constructions
Committee D-1 on Paint, Varnish, Lacquer, and Related Products
Committee D-14 on Adhesives

The details of these programs are known to the majority of the Society's membership but if further information is desired, reference can be made to the annual reports of these various committees.

Association of American Railroads:

The Engineering Division of the AAR is actively engaged in the study of two projects. One is the study of the protection of rail webs with various joint bar lubricants. One installation in connection with this project has developed valuable data during the past five years. The other corrosion research problem pertains to the development of an inhibitor for refrigerator car brine to prevent or alleviate damage to track and bridge structures.

Electrochemical Society:

The Electrochemical Society sponsored a three-day corrosion symposium in October, 1950, and a symposium on Electrode Kinetics in April of this year. Another symposium is scheduled for this year's Fall meeting.

The Corrosion Handbook Committee of the ECS has been reactivated with the following objectives:

1. Enlarge the number of media for which materials are rated, and particularly to attempt a more detailed breakdown of present groupings for which ratings are referred to some other media.
2. Enlarge the list of materials for which ratings are given.
3. Bring present ratings up to date.
4. Include more detailed explanation of the rating scheme.

Federation of Paint and Varnish Production Clubs:

During 1950 the Technical Committee of the New England Production Club continued evaluations of panels exposed in its investigation of "Primers for Ferrous Metals in Atmospheric Exposure."

The original investigation has been extended to include a project on "Surface Preparation of Structural Steel and Its Effect on Life of Subsequently Applied Primer." Seven methods of surface treatment will be used:

Sandblasting
Pickling
Wire-brushing
Flame-cleaning
Phosphoric acid wash
Linseed oil-solvent wash
Vinyl type primer

Substrata will be hot-rolled steel plates, some of which will be preweathered.

National Association of Corrosion Engineers:

One of the important contributions of the NACE to the study of corrosion problems is the sponsorship of short courses in corrosion. The first of these was sponsored by the Tulsa Section followed by a pipeliner's school in the Shreveport Section and a short course at Case Institute of Cleveland.

Stevens Institute at Brooklyn is offering a course in corrosion both semesters this year (1950–1951). A similar extension course is being held at the University of California in Los Angeles.

Several publications were issued by the technical practices committees which included:

First Interim Report on Recommended Practices for Surface Preparation of Steel
First Interim Report on Galvanic Anode Tests
First Interim Report on Ground Anode Tests

National Bureau of Standards:

Noteworthy in the corrosion work of the National Bureau of Standards was the early realization of the value of titanium, and the subsequent exposure testing of titanium and its alloys was begun in 1949.

Work on underground corrosion has been curtailed to meet budget limitations and as a result examination of those specimens removed in 1950 has been delayed.

Study of corrosion in marine and other atmospheres of aircraft alloys in sheet form continues. Study of the variables in salt spray testing was resumed. Experimental work on the corrosion of metals in housing exteriors was completed and a final report is being prepared. A study of the fundamentals of stress corrosion was initiated.

National Research Council (Canada):

The NRC through its Associate Committee on Corrosion Research and Prevention has in effect a program designed to determine reproducibility of the salt spray cabinet test (ASTM Method of Salt Spray (Fog) Testing, B 117 – 49 T) on painted steel, electroplated steel, 245-T aluminum, humidity tests on painted steel and electroplated steel, and Weather-O-Meter tests on painted steel. Similar panels will be exposed to industrial and marine atmospheres.

In the field of atmospheric corrosion testing, the Division of Building Research has completed arrangements for corrosion test sites at Ottawa, Ont., Halifax, N. S., Montreal, Que., and Saskatoon, Sask. An area at Baker Lake, about 150 miles northwest of Churchhill, Man., is expected to become available this year.

In the field of Fundamental Corrosion Research, four research grants from government funds have been made available for study on the following projects: aluminum oxide barrier layers, unidirectional stress corrosion layers, study of single crystals, potential-pH diagrams and polarization studies on magnesium.

Subcommittee members who are mostly university staff members are carrying out research on the following topics:

Inhibition of corrosion
Marine protective coatings
Marine cathodic protection
Gray tin formation
Unidirection stress corrosion
Aluminum oxide barrier layers
Single crystal properties
Electrode mechanism

National Research Council:

Corrosion activity of the NRC has been confined to operations of the Prevention of Deterioration Center which is concerned with the deterioration of materials. The NRC has also agreed to act as a repository for data to be available for future revisions of the Electrochemical Society's Corrosion Handbook, for agencies of the Department of Defense, and for publications desiring such information.

Office of Naval Research:

Current investigations sponsored under the Fundamental Research Program of the ONR include studies on:

Nature of passivity
Oxidation
Mechanism of corrosion reactions
Passivity studies on stainless steels
Effect of stress on metal-ion exchange in solution
Effect of hydrogen on corrosion of iron and steel
Oscillograph polarography
Metal-salt reactions at high temperatures

Related ONR programs include:

Role of hydrogen in embrittlement of steels
Effect of environment on creep of metals
Influence of liquid media on creep of metals
Effect of environment on high-temperature strenght of metals

In addition to the above reports, the American Society for Metals, The American Chemical Society, and the American Society of Heating and Ventilating Engineers submitted reports indicating that no corrosion projects are under way at the present time. Reports are expected from some of those members that have not already submitted accounts of their corrosion work.

Twenty-five Years of Metallography

PRESENTED by J. R. Villela, U. S. Steel Co., as the 1951 Howe Memorial Lecture of the American Institute of Mining and Metallurgical Engineers and now in published form, this profusely illustrated and instructive treatise covers the achievements which have contributed most to the progress of microscopical metallography in the past twenty-five years. Subjects discussed include the following:

1. Recognition of the existence of a layer of disturbed metal formed during polishing and its elimination by the practice of alternate polishing and etching or electropolishing.
2. Investigation by Bain and Davenport into the decomposition of austenite that led to the development of the isothermal transformation diagram.
3. The electron microscope and the first progress report of Subcommittee XI on Electron Microstructure of Steel, ASTM Committee E-4 on Metallography, demonstrating that high fidelity electron micrographs of steel can be obtained by present-day replica techniques.
4. Developments in the metallurgical microscope including conical illumination, polarized light, dark field and phase contrast illumination, coated lenses, and interference filter.
5. Rebirth of interest in color metallography.
6. Ultraviolet microscopy.

This article is one which everyone interested in metallography should read. It is published in Vol. 3, No. 8 (August, 1951) issue of the *Journal of Metals*, Am. Inst. Mining and Metallurgical Engrs., Inc., 29 W. 39th St., New York 18, N. Y.

TECHNICAL COMMITTEE NOTES

Columbium and Tantalum in Austenitic Stainless Steels

A PROBLEM of major importance under discussion in Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and related alloys for many months has been that of modifying the specifications under its jurisdiction covering austenitic stainless steels stabilized by the addition of columbium in view of the very grave limitations of supply of this element.

The recommendation made below is applicable to all austenitic stainless steels stabilized by columbium in all forms covered by the specifications over which Committee A-10 has jurisdiction, whether these specifications deal with sheets, plates, bars, forgings, castings, pipe, or other forms.

It appears assured that the "super-alloys" will be awarded the highest priority with respect to the supply of columbium. For these purposes no substitute is known.

For the present some columbium and tantalum, associated together in the form of combined ferro-alloy, is available for other uses. However, there appears to be no possibility of predicting the ratio of these two elements that will be available in such ferro-alloy in the near future, or the changes that may be made in this ratio from time to time, or what the total availability may be. Consequently, provision must be made for a changing situation that cannot be foreseen with any degree of exactitude.

There is not yet sufficient detailed knowledge of the properties of the steels over the full range of such an addition, from almost total columbium on the one hand to almost total tantalum on the other hand. However, much investigative work is in progress, the results of which should be usable by contracting parties as it develops. There is already some indication that perhaps two types may emerge (especially in respect to the columbium to tantalum ratio), one principally for high-temperature use and the other better adapted for resistance to certain types of chemical attack.

There is appended hereto a summary of work done to date on the part of many investigators and workers in the field, dealing with the relation between columbium steels in accordance with present specifications and similar steels with a columbium to tantalum ratio of approximately 2:1.

In connection with the statement above regarding reservation of commercially pure columbium for the "super-alloys," it should be noted that additionally some of the same may be necessary for welding wire as it appears to be the consensus that only such welding rod is fully satisfactory for this purpose.

In view of all the above, Committee A-10 recommended to the Society the following modification of the above specifications:

"In view of the limited availability of columbium (with the heretofore usual small percentage of tantalum) the stabilizing addition to type —— shall consist of columbium plus tantalum. The ratio of columbium to tantalum (in relation to the carbon content of the steel) and the maximum of each element, or of one of them, or of the two combined, shall be determined in accordance with the requirements of the end use and shall be as mutually agreed upon by producer and purchaser."

These changes, approved by the Administrative Committee on Standards and designated as Emergency Alternate Provisions, appear on p. 28.

JEROME STRAUSS

Chairman, ASTM Committee A-10

APPENDIX

COLUMBIUM-TANTALUM ALLOYS AND THEIR USE IN TYPE 347

REPORT OF SPECIAL SUBCOMMITTEE OF COMMITTEE A-10

BY H. A. GROVE[1]

The object of the following data is to show that the substitution of the presently available 40 per cent columbium-20 per cent tantalum ferro-alloy for the standard type of ferrocolumbium previously used is practicable. The ferrocolumbium available when the type 347 steel composition limits were established contained 5 to 10 per cent tantalum. This amount at that time was considered of minor importance and was disregarded. The Cb:Ta ratios tested so far appear to indicate that they are as effective as columbium alone when used as chemical stabilizers.

The results shown in this report are an accumulation of test data taken from experimental and production heats made by steel producers as well as ferro-alloy producers and combine tests on bars, castings, and flat products such as sheet and strip.

It should be pointed out that there is not a satisfactory method of chemically analyzing for the two elements separately by the so-called wet method. A spectrographic analysis appears to be the only satisfactory method at present. The values shown in Table I are by that method.

The next subject studied by the producers of ferro-alloys and stainless steels was the effect of varying Cb:Ta ratios on the mechanical properties of type 347 as previously established. The mechanical properties were studied both at room tem-

TABLE I.—CHEMICAL ANALYSES.

Heat	Composition, per cent							
	Carbon	Manganese	Silicon	Chromium	Nickel	Columbium	Tantalum	Molybdenum.
No. A1E....	0.059	1.50	0.45	18.20	10.70	0.71	0.06	..
No. A2E....	0.057	1.55	0.40	18.10	10.75	0.60	0.26	..
No. A3E....	0.057	1.45	0.35	18.40	10.80	1.01	0.40	..
No. B1C....	0.07	1.50	0.70	18.48	10.24	0.78	0.025	..
No. B2C....	0.05	1.59	0.68	18.33	10.09	0.57	0.16	..
No. B3C....	0.05	1.62	0.72	19.81	11.29	0.20	0.87	..
No. B4C....	0.05	1.50	0.69	18.29	9.93	0.1[c]	1.15	..
No. B5C....	0.022	1.39	0.48	18.32	9.04	0.1[c]	0.57	..
No. C1C....	0.05	1.44	0.70	17.03	11.76	0.64	0.03	2.50
No. C2C....	0.06	1.47	0.68	17.28	12.18	0.55	0.11	2.48
No. C3C....	0.06	1.44	0.77	17.08	12.02	0.25	0.78	2.50
No. C4C....	0.05	1.36	0.67	16.78	11.76	0.1[c]	1.11	2.30
No. C5C....	0.021	1.32	0.56	16.60	11.88	0.1[c]	0.44	2.45
No. D1A....	0.059	..	..	18.92	11.10	0.34	0.33	..
No. D2A....	0.058	..	..	18.88	11.14	0.52	0.42	..
No. D3A....	0.056	..	..	18.79	11.10	0.63	0.52	..
No. D4A[a]...	0.062	..	..	18.73	11.02	0.79	0.12	..
No. D5A[a]...	0.058	..	..	18.37	11.15	0.77	0.1[c]	..
No. D6A[b]...	0.052	..	..	..	..	0.71	0.09	..
No. D7A[b]...	0.051	..	..	..	..	0.69	0.04	..

[a] Mean of 15 heats.
[b] Mean of 10 heats.
[c] Nominal.

[1] Claymont Steel Corp., Claymont, Del.

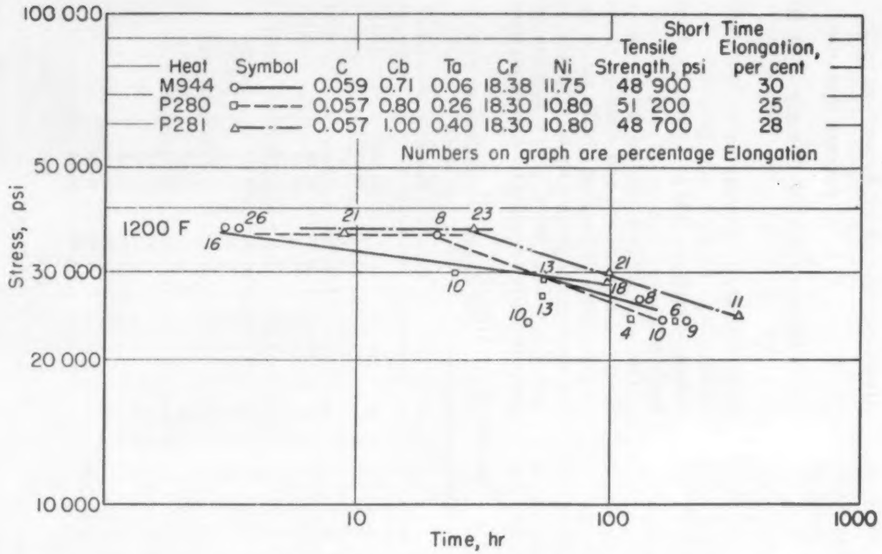


Fig. 1.—Stress Rupture Values of 18–8 Cb Versus 18–8 CbTa Sheet, 0.065 in. Thick.

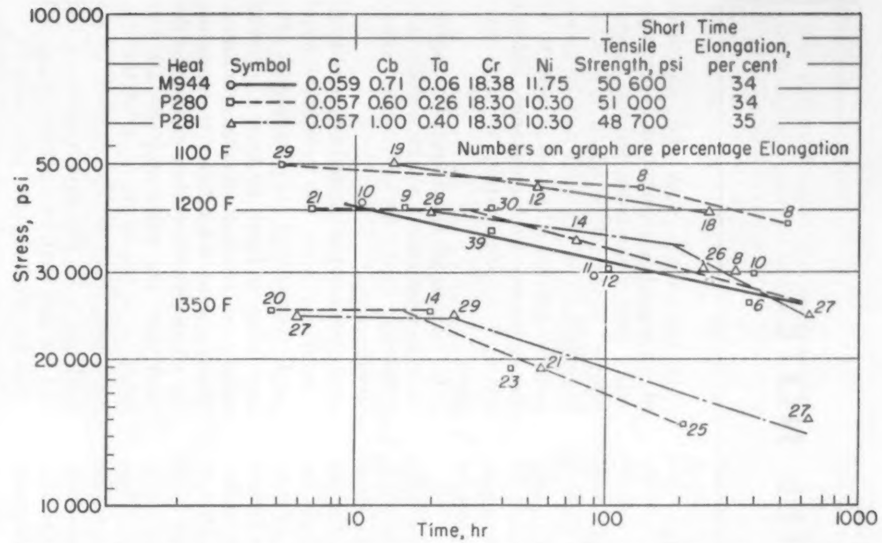


Fig. 2.—Stress Rupture Values of 18–8 Cb Versus 18–8 CbTa $\frac{5}{8}$-in. Diameter Bar Stock.

Columbium	0.78	0.57	0.20	0.1	0.1
Tantalum	0.025	0.16	0.87	1.15	0.57
Carbon	0.07	0.05	0.05	0.05	0.022
Molecular equivalent $\frac{Cb}{C}$	11.1	13.1	12.9	11.5	12.95

TABLE II.—MECHANICAL PROPERTIES.[a]

Heat	Type Sample[b]	Temperature, Fahr	Yield Stress, psi	Tensile Strength, psi	Elongation, per cent	Reduction Area, per cent
No. A1E...	Sheet	Room	39 100	87 900	46.5	..
	Sheet	1200	..	48 900	30	..
	Bar stock	1200	..	50 600	34	61
No. A2E...	Sheet	Room	37 100	90 300	51	..
	Sheet	1200	..	51 200	25	..
	Bar stock	1200	..	51 300	34	63
No. A3E...	Sheet	Room	38 500	89 400	46	..
	Sheet	1200	..	48 700	28	..
	Bar stock	1200	..	54 000	35	55

[a] All samples air-cooled from 1950 F.
[b] Sheet = 0.05 in. thick. Bars = 0.23 in. diameter.

TABLE III.—RESULTS OF STRESS RUPTURE TESTS AT 1200 F.[a]

Heat	Type Sample[b]	Stress psi	Elongation, per cent	Hours to Fracture
No. A1E......	S	25 000	9	175
	S	30 000	13	73
	S	35 000	16	3.6
	S	27 500	8.5	111
	B	25 000	..	168 unbroken
	B	30 000	11	90
	B	35 000	10	45
	B	40 000	10	11.7
No. A2E.	S	25 000	8	159
	S	30 000	12.5	125
	S	35 000	25	4
	B	25 000	7.5	437
	B	30 000	16	365
	B	35 000	39	41
	B	40 000	9	16
No. A3E......	S	25 000	11	305
	S	30 000	18	93
	S	35 000	21	33
	B	25 000	..	460 unbroken
	B	30 000	..	168 unbroken
	B	35 000	..	168 unbroken
	B	40,000	..	19 unbroken

[a] All samples air-cooled from 1950 F.
[b] S = Sheet, 0.05 in. thick. B = Bars, 0.25 in. diameter.

TABLE IV.—ESTIMATED STRESS IN PSI FOR RUPTURE AT 1200 F.

Heat	Sample[a]	10 hr	100 hr	1000 hr
No. A1E.	S	34 000	29 000	20 000
	B	41 000	30 000	22 000
No. A2E.	S	35 000	30 000	20 000
	B	42 000	34 000	25 000
No. A3E.	S	38 000	29 000	23 000
	B		Tests incomplete	

[a] S = Sheet, 0.05 in. thick. B = Bars, 0.25 in. diameter.

perature and at elevated temperatures. The results shown in Tables II, III, and IV and Figs. 1 and 2 show there is no significant effect resulting from the use of various ratios of columbium to tantalum within the limits studied.

The effect of the Cb:Ta ratios on the corrosion resistance of type 347 was studied by both the Strauss and Huey tests. Various ratios of columbium to tantalum and to carbon were covered in the investigation. From the data developed in the nitric acid tests it would appear that tantalum is as effective as columbium as a chemical stabilizer. Results of such tests are shown in Table V and Figs. 3 and 4.

In summarizing all results to date, it would appear that the proposed 40 per cent columbium-20 per cent tantalum alloy can be used as a substitute in type 347 for the former ferrocolumbium alloy without detrimental effect to either its mechanical or corrosion resisting properties under the conditions thus far studied.

Acknowledgment:

Acknowledgment is given to the following companies in making these data available:

Allegheny Ludlum Steel Corp.
Armco Steel Corp.
The Carpenter Steel Co.
Crucible Steel Co. of America
Lebanon Steel Foundries
Republic Steel Corp.
U. S. Steel Corp.
Union Carbide & Carbon Co.

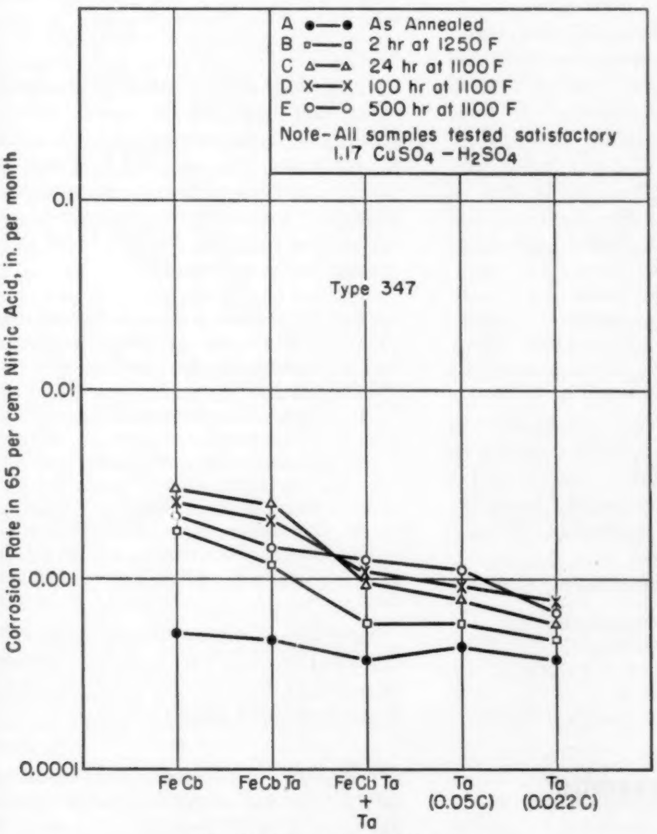


Fig. 3.—Corrosion Rates of Columbium-Tantalum Alloys—Straus Test.

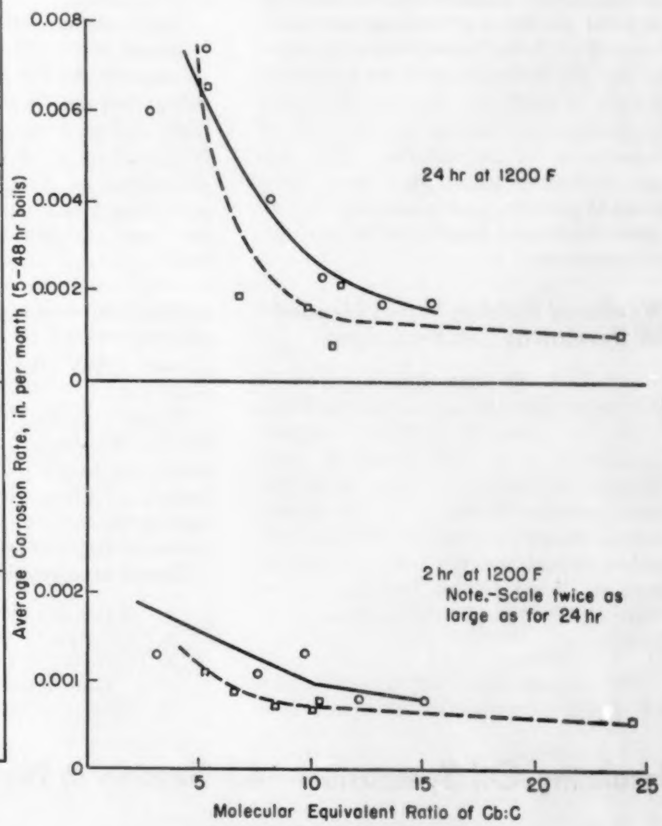


Fig. 4.—Corrosion Rates of Columbium-Tantalum Alloys—Huey Test.

TABLE V.—CORROSION RATE IN BOILING 65 PER CENT NITRIC ACID. (Average of 5 Boiling Periods Unless Otherwise Indicated, in. per Month.)

Heat	Sensitizing Treatment: Annealed 1950 F	1 hr 1250 F	2 hr 1250 F	24 hr 1250 F	2 hr 1625 F	2 hr 1100 F	24 hr 1100 F	100 hr 1100 F	500 hr 1100 F	2 hr 1625 F, 2 hr 1250 F	2 hr 1625 F, 24 hr 1250 F
No. B1C..	0.00057	...	0.00207	....	...	...	0.00349[c]	0.00319	0.00251	....	....
No. B2C..	0.00057	...	0.00114	....	...	...	0.00257	0.00211	0.00133	....	....
No. B3C..	0.00040	...	0.00060	....	...	...	0.00090	0.00099	0.00103	....	....
No. B4C..	0.00055	...	0.00063	....	...	...	0.00083	0.00095	0.00100	....	....
No. B5C..	0.00043	...	0.00053	....	...	...	0.00063	0.00075	0.00058	....	....
No. C1C..	0.00174	...	0.02900[a]	0.17900[a]	0.00239	...	....	...	...	0.00548[b]	0.01064[a]
No. C2C..	0.00142	...	0.01282[a]	0.05860[a]	0.00167	...	....	...	...	0.00477[b]	0.0434[a]
No. C3C..	0.00131	...	0.00403[b]	0.12950[a]	0.00384	...	....	...	...	0.00495[b]	0.00433[a]
No. C4C..	0.00129	...	0.00597[a]	0.13000[a]	0.00312	...	....	...	...	0.00570[a]	0.00670[a]
No. C5C..	0.00109	...	0.00776[a]	0.14820[a]	0.00106	...	....	...	...	0.00374[b]	0.01280[a]
No. D1A..	...	0.00120	....	....	...	0.00078	....	...	...	....	....
No. D2A..	...	0.00075	....	....	...	0.00060	....	...	...	....	....
No. D6A..	...	0.0013	....	....	...	...	....	...	...	....	....
No. D7A..	...	0.0013	....	....	...	...	....	...	...	....	....

[a] Rate for 2 boiling periods.
[b] Rate for 3 boiling periods.
[c] Rate for 4 boiling periods.

Activity of Committee C-8 on Refractories Discussed at Fall Meeting

IT WAS evident at the fall meeting of Committee C-8 on Refractories that there was considerable activity among the several subcommittees dealing with the many phases of study in the testing of refractories. The committee had an excellent attendance at its meeting, which was held on September 13 at Bedford Springs, Pa. This meeting preceded a two-day session of the Refractories Division of the American Ceramic Society.

In reviewing the reports of the several subcommittees presented at the meeting, some of the items of interest are noted herewith. A task group was authorized within the Subcommittee on Industrial Survey to study and develop the rather comprehensive subject of methods of installation of refractories. The Research Subcommittee has been interested in porosity and grain and the use of the third-point loading in the modulus of rupture test.

The several sections dealing with tests for measuring properties of refractories have programs under way, many of which were referred to in the article published in the September Bulletin dealing with standardization activities of technical committees. Work at the University of Illinois was described dealing with research in the use of dynamic apparatus in the study of modulus of elasticity of refractory materials. It was made known that data are being collected for a proposed method of test for porosity and permanent volume change. The need was expressed for developing a test method for use in measuring carbon monoxide disintegration.

The Subcommittee on Heat Transfer reported that equipment described and specified in ASTM standards, for measuring thermal conductivity, has been built and used successfully in England. A current project under way in the Subcommittee on Specifications is that of reviewing Canadian Specifications and the latest revision of Federal Specifications.

There was considerable discussion on the varied use of the terms "mullite" and "sillimanite" in connection with refractories now produced and sold. It was felt very desirable to crystallize the thinking by the establishment of an accepted definition of these terms. When this has been accomplished, it will then be possible to set up classifications of this group of materials.

A subject of considerable interest is the proposed research program presented by the Subcommittee on Special Refractories which was authorized at the last meeting of the committee. It was felt very necessary to enlist the cooperation of all other organizations which have a direct interest in this group of refractories.

Progress is somewhat slow in developing test methods on carbon refractories, due to the considerable variation in products. A renewed interest in petrography as a means of studying refractory materials was expressed, and action was taken to reactivate the subcommittee on petrography.

Weathered Building Stones Needed for Developing Test Procedures

IN THE development of test procedures for measuring the properties of natural building stones, Committee C-18 has found it very desirable to collect test data on weathered building stones. The accumulation of samples is not too easy a task, and an appeal has been made, calling for samples of weathered building stones from old buildings being repaired or torn down.

The requirements for these samples are noted herewith as well as other pertinent information needed. An ideal specimen would be 12 by 12 by $2\frac{1}{2}$ in. in size. Any specimen is better than none at all.

Where spalling or exfoliation or serious disintegration of the surface of stone has taken place, please collect a sample of scales and powder from the weathered surface, preferably during a period of dry weather.

For all samples please note:

1. Name of building or structure.
2. Location or "address."
3. Date of erection, if known; if not, approximate age.
4. Kind of stone; quarry if known.
5. What kind of stone or material lay above the spalled or weathered stone in the building or structure.
6. Type and condition of mortar beds and joints.
7. Presence or absence of concrete backing.
8. Original surface finish of stone.
9. Is stone veneer or heavier stone?
10. Name of contractor and/or setter.
11. Comment on local environment.

Send samples to or communicate with National Bureau of Standards, Attention Mr. D. W. Kessler, Chief, Building Stone Section, Washington, D. C.

Insulating Oil Symposium—4th Session in November

A SYMPOSIUM on Uninhibited Petroleum Electrical Insulating Oils will be held Wednesday evening, November 14, at the General Brock Hotel at Niagara Falls, Ontario, in conjunction with the Fall meeting of ASTM Committee D-9 on Electrical Insulating Materials. This will be the fourth session of a series of Symposia on Insulating Oils to be held by Subcommittee IV on Liquid Insulation. In recent years, Subcommittee IV, with E. A. Snyder as chairman, has sponsored a series of symposia relating to somewhat controversial discussions of the properties and performance of insulating liquids and methods of test. The three previous symposia were held in October, 1946, June, 1947, and March 1949, and all have appeared in ASTM publications.

The November Symposium will be based on the results of the Subcommittee's cooperative study on the correlation of laboratory tests with service performance of uninhibited insulating oils, under the direction of F. M. Clark. This cooperative study has been concerned with 18 large power transformers in actual service by various utility companies in the United States in order to obtain a wide variety of operating conditions typical of American practice. The Subcommittee IV cooperative tests were started about 7 yr ago with 19 independent laboratories participating in the very comprehensive program. Oil samples for tests by all the cooperating laboratories have been removed at about one-year intervals during normal operation by the different utility companies.

Originally one of the main objectives of the tests was to determine the significance of ASTM Tentative Methods of Test for Sludge Formation in Mineral Transformer Oil (D 670–42 T) in evaluating the resistance to oxidation of various types of new and used oils. However, it has been the general practice in this test program for the various laboratories to make other selected tests commonly used as criteria of oil degradation, such as acid number, interfacial tension, color, dielectric strength, power factor, resistivity, and steam emulsion number.

The evaluation of the sludge test results with service performance of the oil in all the transformers as well as the correlation of the data of other tests with service performance has been recognized to be a very difficult and perplexing task. This is the main purpose of the November Symposium. It is hoped that free and open discussion leading to

its eventual interpretation will enable Subcommittee IV, at some later date, to prepare a brochure which will indicate how much weight can be given to the various test methods for forecasting the service life of transformer insulating oil.

Three papers will be presented for discussion as follows:

"Evaluation of Mineral Transformer Oil During Service, Part II—a Further Correlation of Oil Characteristics After Continued Period of Service," by F. M. Clark, General Electric Co.

"Evaluation of Laboratory Tests as Indicators of the Service Life of Mineral Transformer Oils," by T. A. McConnell, Detroit Edison Co.

"Discussion of ASTM Round-Robin Test Results on Transformer J," by R. G. Call, American Gas and Electric Service Corp.

The first of these papers will be based on the analysis of all the test results now available and will present the relative merits of the various laboratory tests studied. The other two papers will describe the condition of the transformers examined in a further effort to correlate the laboratory data obtained on the various oils tested with the actual condition of the transformers examined. Many controversial issues on this general subject will thus be brought out for open and full discussion.

Committee D-2 on Petroleum Products and Lubricants

A Review of Committee Work and Summary of Future Work

THE working committees of ASTM Committee D-2 on Petroleum Products and Lubricants presented reports to the committee in June, summarizing their work of the past year. Their work for the future year has been summarized and is presented herewith.

Technical Committee A on Gasoline has continued its studies of Gasoline Specifications. An invitation was broadcast to users and producers of gasoline to submit opinions on changing the expression of octane values as set forth in ASTM D 439, Specifications for Gasoline, from "Motor Method Octane Numbers" (ASTM D 357) to "Research Method Octane Numbers" (ASTM D 908). Very few comments were submitted from outside the membership of technical Committee A, and this dearth of comment may mean (1) that the sources most competent are in Technical Committee A or are represented on the committee, or (2) that the users of gasoline are indifferent to the method used for expressing octane values. At any rate, there was insufficient demand for a change to justify discard of the Motor Method Octane Number this year. Technical Committee A is continuing to study the matter.

Liaison has been established with the Technical Committee on Fuels and Lubricants of the Federal Specifications Board. It is hoped that by this means FSB specifications can be kept better in line with ASTM specifications.

Studies are being conducted in cooperation with Research Division V on the significance of Method D 529 – 49, Test for Oxidation Stability of Gasoline, as a means of predicting the storage stability of present-day gasolines.

Technical Committee B on Lubricating Oils is continuing the study of the matter of a "use classification" of motor oils. An informal symposium on the subject was held in Washington in February which resulted in a Special Study Committee to develop recommendations. The Special Study Committee is working closely with the Lubrication Committee of the Division of Marketing, American Petroleum Institute.

Studies on the oxidation, corrosion, spreading, and performance of instrument oils are continuing.

Technical Committee C on Turbine Oils has continued the study of the performance and properties of turbine oils.

Section I on Oil Systems, which also functions as a joint ASME-ASTM Committee on Turbine Lubrication, developed a Recommended Practice for the Purification of Turbine Oil which has been proposed to ASME for publication. The ASME plans to issue a pamphlet containing two Recommended Practices which were also developed by this group—"Preparation of Turbine Lubricating Systems before Service" and "Cleaning Turbine Lubricating Systems after Service."

Additional Recommended Practices on Preparation of Turbine Systems for Lay-up and on Design of Turbine Lubricating Systems are under development.

The program for next year includes: a study of procedures to determine emulsifying characteristics, a program to test the compatability of new and used turbine oils, and a study of short-term oxidation tests.

Section I of *Technical Committee F on Diesel Fuels* acts as liaison between Technical Committee F and the Coordinating Research Council, Inc., Diesel Fuel Division. The CRC is a research organization, jointly sponsored by the American Petroleum Institute and the Society of Automotive Engineers, which aims to encourage and promote the arts and sciences by directing scientific research in developing the best combinations of fuels, lubricants, and equipment powered by internal combustion engines.

Currently, this TCF-CRC cooperation includes a study of the front-end volatility effect on engine warmup, the completion of a full-scale railroad test, a study of the corrosive effects of diesel fuels, a study of methods for estimating cetane numbers, and other problems.

The task of keeping specifications D 975 for Diesel Fuel in line with changing commercial needs is one which constantly occupies Section II, Specifications. Work on this problem led to a revision of D 975 flash point specification for No. 2D grade diesel fuel from "100 F or legal" to "125 F or legal." The desire to bring D 975 to a greater degree of utilization prompted Technical Committee F to change the "specification" to a "classification."

Technical Committee G on Lubricating Greases has a long-range program of work under way to develop new methods of test for lubricating greases which deals with improvement of existing methods of test, development of new apparatus and procedure for semifluid greases, evaluation of high-temperature greases for performance, evaluation of wheel bearing greases and sub-zero torque properties, evaluation of water resistance of greases, and thixotropic behavior of greases.

Of immediate concern is the development of laboratory predictions for bleeding and storage stability of greases, the measurement of deleterious particles in greases, and a method for the measurement of the effect of grease on copper. These projects may be completed during the coming year.

Since Method D 128, Analysis of Grease, was developed many new grease formulations have been made commercially available, some of which, incorporating hydroxy-acid soaps, synthetic lubricating fluids and non-soap gelling agents, cannot be analyzed by the method. Therefore, Technical Committee G plans the development of required new analytical procedures.

An ASTM Symposium on Fretting Corrosion is being organized by Technical Committee G for presentation at the June, 1952, Society meeting in New York.

Technical Committee H on Light Hydrocarbons is preparing, with the cooperation of the Office of Rubber Reserve, a Committee D-2 Symposium on Newer Methods of Analysis for Butadiene, which will be held during the February meeting of the committee. Its purpose is to bring the latest developments in chemical methods of analysis, physical methods of testing, and in apparatus before those engaged in the manufacturing of butadiene or products entering into its manufacture.

Section II, Liquefied Petroleum Gas, has initiated cooperation with the Natural Gasoline Association of America; the California Natural Gasoline Assn.; ASTM Committee D-3; and also with Divisions II on Measurement and Sampling, III on Elemental Analysis, and VIII on Volatility of Committee D-2, with respect to proposed tests on vapor pressure, total sulfur and other test methods related to liquified petroleum gas.

Technical Committee J on Aviation Fuels has formed a new Section VII on Jet Fuels to study the fast-developing subject of jet fuels and make appropriate recommendations in this field.

Technical Committee J is continuing the study of the performance of aviation fuels in order to keep their activity in step with latest developments.

The program of *Technical Committee K on Cutting Fluids* includes the development of new methods for determining sulfur in cutting fluids and a study of mechanical methods for the laboratory evaluation of cutting fluids.

An important accomplishment of *Research Division I on Combustion Characteristics* was the completion of a test program to determine the reproducibility of ASTM-DCC 6, Method of Test for the Comparison of Knocking Characteristics of Aviation Fuels under both Lean and Rich Conditions. Experience gained with the method as a result of this test program pointed the way to improvements in equipment and modifications of operating technique.

Other work within the Division centered around improvements and revisions of the five methods contained in the ASTM Manual of Engine Test Methods for Rating Fuels.

A new instrument cabinet was adopted. Exhaust value rotators were approved as optional equipment in D 357 and D 908. It was decided to continue pressurization experiments on D 908, Research, D 357, Motor and D 614, Aviation knock test methods in order to attempt to eliminate the effect of barometric pressure variations on results. A project to extend the Research and Motor Methods to fuels well above 100 octane is under way.

The Division worked on a revision of the procedures to be followed in the certification of new batches of primary reference fuel standards for engine testing, calibration of secondary reference standards for engine knock testing, and in the definition of National Knock Rating Standards, against which the commercial primary reference fuels, *iso*octane and *n*-heptane, are calibrated.

Method D 908, Test for Knock Characteristics of Motor Fuels by the Research Method, was adopted as a standard method this year. Three new methods for the knock rating of small samples are being published as information.

Two long-range and very extensive projects are nearing completion in Division II on *Measurement and Sampling*. The first of these has been under way since 1946 with the cosponsorship of the British Institute of Petroleum and deals with the development of Petroleum Measurement Tables based on the three most widely used systems of measurement—U. S. units, British (Imperial) units, and metric units. The three systems are interrelated to meet the world-wide need for a uniform and authoritative publication to serve as a basis for standardized calculations of measured quantities of petroleum, regardless of point of origin or destination.

The second large-scale project is the preparation of a method of calibrating liquid containers larger than a drum. This project has been under way for over five years and has entailed considerable study and research of available information on tank calibration. A review draft on upright tanks has been prepared.

The Division is actively engaged in revising, improving, and enlarging the ASTM Manual on Measurement and Sampling of Petroleum and Petroleum Products.

A full roster of work will occupy Sections A, Sulfur; B, Chlorine; C, Phosphorus; D, Metals; E, Trace Elements; F, Tetraethyllead, and G, Carbon, Hydrogen, Nitrogen, and Oxygen, of *Research Division III, Elemental Analysis.*

The Division envisages the following projects:

Development of a method for determining mercaptan sulfur in jet fuels and gasolines.

A cooperative program to test a modified version of the CO_2-O_2 lamp method, published as information in 1949, as a possible method of test for determining sulfur in liquefied petroleum gas and butadiene.

Development of an accurate and sensitive method for the determination of chlorine in lubricating oils and lubricating oil additives.

A study of Method D 811, Chemical Analysis for Metals in Lubricating Oil, to prepare an abbreviation of the method for the determination of barium, calcium, and zinc in new oils.

A study and evaluation of emission spectrographic methods for the determination of metals in petroleum products.

A program to develop a method for the determination of ash, sodium, and vanadium in residual fuels.

A program to adapt Method D 1018, Test for Hydrogen in Petroleum Fractions by the Lamp Method, to wax.

Completion of a method of test for the determination of tetraethyllead in gasolines by a polarographic method.

Technical Committee G, Lubricating Greases, was given the task of evaluating the results for lead obtained in the cooperative study to modify Method D 810, Test for Sulfated Residue Lead, Copper, and Iron in Lubricating Oils, to include analysis of lead in grease. Cooperative work with Technical Committee G on a method for lead in grease in continuing.

It was decided to restrict Method D 526–46 T, Test for Tetraethyllead in Gasolines, to samples free of sediment.

Research Division IV on the Analysis of Petroleum Products for Hydrocarbon Type reports progress in its program as follows:

The standardization of the fluorescent indicator adsorption method for determination of aromatics and olefins in gasolines and jet fuels.

The standardization of a silver-mercuric nitrate method for determination of olefins in gas samples.

The completion of a cooperative program and issuance of a method for the infrared analysis of cracked C_4 streams.

Addition of necessary data for determination of purity by freezing point for several new compounds.

A method for the precise determination of refractive index and refractive dispersion is being completed.

Cooperative data obtained at the Bureau of Standards show that the ASTM method and the Bureau method for determination of purity of *iso*octane give the same results within the accuracy of the method.

The extensive cooperative program of methods for analysis for jet fuels has been completed. This program has given much useful information but has not yet provided a standard test method. Work is being continued.

Research Division V on the Analysis of Fuels plans to complete a cooperative program to evaluate a proposed steam jet method for determining gum content in aircraft turbine and jet fuels. The method uses steam instead of air in the evaporating procedure. Five samples of experimental jet fuels were distributed to sixteen laboratories to be examined with respect to gum content and evaporation temperatures of 400, 450, and 500 F. Results from nine laboratories have been received. Further cooperative work on samples received from Wright Field is to be started immediately, using 450 F as the evaporating temperature.

A reconsideration of the "break point" definition in Method D 525, Test for Oxidation Stability of Gasoline, for gasoline types which do not break in the preferred manner is planned. A program to determine the gum content in gasoline containing oil will be completed.

Research Division VI on Analysis of Lubricants worked mainly on three topics: Saponification Number, Insoluble Matter in Ashphaltenes in New Lubricating Oil, and Carbon Residue.

The Division is cooperating with the Institute of Petroleum (Great Britain) in developing a method for determining the insoluble matter in ashphaltenes in new lubricating oils. It was decided that to specify an "ASTM Grade Naphtha" or its I. P. equivalent, "I. P. Spirits," as the solvent in the method would lead to difficulty. Therefore, the Division is determining what proportions of a blend of two pure hydrocarbons, *n*-heptane and cyclohexane, correspond to an "ASTM Precipitation Naphtha." The centrifuge technique as followed in Method D 893, Normal Pentane and Benzene Insolubles in Used Lubricating Oils, will be applied to the new method.

Method D 189, Test for Carbon Residue of Petroleum Products by the Conradson Method, will be studied during the coming year.

Research Division VII on Flow Properties has revised and enlarged Method D 445, Test for Kinematic Viscosity, particularly the calibration procedure. The proposed revised method will be published as information.

An investigation into the practicability of using a pure hydrocarbon to supplement or replace freshly distilled water as the basic viscosimeter calibration standard was undertaken. If found acceptable, the cumbersome corrections for surface tension can be eliminated.

Reliability and ease of handling are the factors being considered in setting up a

method for calculating the viscosity of oil blends. The advisability of such a method is being determined.

A cooperative study of Method D 97, Test for Cloud and Pour Points, as to its reproducibility for measuring the cloud point of low-pour-point products indicates that widely varying results, ranging from -50 to -100 F, were obtained on the same sample. Work is continuing.

Research Division VIII on Volatility has a test program under way to determine the repeatability and reproducibility of the proposed method for vapor pressure of liquid petroleum gas which Technical Committee H is developing.

A test program is being initiated to determine the possibility of including a null point head and manometer as a substitute for Bourdon gages in the Reid vapor pressure measurement.

The program under way to provide precise distillation data for use in conjunction with the API project to refine vapor pressure – temperature correlations, now being conducted at Northwestern Institute of Technology, will continue.

For several years *Research Division IX on Color* has been interested in the problem of placing petroleum colorimetry on a more fundamental basis.

Currently, the Division is considering a new color scale defined in fundamental spectrometric units which slightly extends the present ASTM Union Colorimeter Scale (D 155). The essential differences between the currently proposed scale and the Union scale are: The color differences between color standards are uniform, and these differences are smaller, which means that the new scale will specify more than the current twelve Union colors.

The Division is considering the development of a color scale for pharmaceutical petrolatums either within the new scale or as a separate scale.

Development of glass color standards for aviation gasolines has been started.

A revision of Method D 156, Test for Color of Refined Petroleum Oil by Means of Saybolt Chromometer, is planned.

Research Division X on Corrosion Tests plans study of Method D 130, Test for Free and Corrosive Sulfur in Petroleum Products (Copper Strip Test) to extend the method for testing of paint, varnish, and lacquer naphthas. The study will be directed to the use of a simple enclosed container to confine volatile samples at 212 F. The Division will investigate the use of this apparatus to replace the air-well unit used for aviation gasoline in the method.

The need for a standard humidity cabinet and standardized humidity cabinet tests for use by all branches of industry and government has spurred the recent formation of a new Section on Humidity Cabinet Tests.

Research Division XII on Graphite Tests completed its organization in 1951 for the purpose of developing and standardizing methods for testing graphite used as component of a lubricant or as a lubricant. Work is under way to develop definitions of various grades of graphite falling within the scope of the Division and to develop methods of test for chemical analysis, abrasiveness, particle size, and sampling.

Subcommittee I on Pharmaceutical Tests is cooperating with Research Division VII, Section E, Wax Products, in determining the suitability of amber petrolatum as a reference standard for calibrating and checking the mechanical condition of the grease penetrometer employed in Method D 937, Test for Penetration of Petrolatum.

Preliminary work has been done in setting up a method of test for measuring the color of pharmaceutical petrolatums in cooperation with Research Division IX. Plans are being laid to obtain the assistance of a color instrument manufacturer in developing the method.

Subcommittee XVII on Plant Spray Oil Tests prepared revisions of Method D 447, Test for Distillation of Plant Spray Oils, and D 483, Test for Unsulfonated Residue of Plant Spray Oils, in a cooperative effort with the Pacific Insecticide Inst. The subcommittee will test the shaking machine used in Method D 483.

The *Special Study Committee on Extreme Pressure Properties* is developing a method for the measurement of extreme pressure properties of oils using the Timken test machine. A report on the cooperative testing of the method is being prepared. Future work will attempt to extend the method to include greases. The study Committee will try to develop a standard material, possibly a repeatedly available additive, for use as a comparison and calibration standard with the Timken test machine.

The *Coordinating Division on Nomenclature* has given serious consideration to a definition of "lubricating grease." A new approach to the probelm is being discussed.

The basic problem of obtaining acceptance and general usage of the recommendations of the Coordinating Division on Nomenclature has been considered.

The Division has recommended that ASTM Committee E-8 on Nomenclature and Definitions set up a subcommittee on dictionary usage in which representatives of the dictionary firms and the men on Committee E-8 could exchange information to their mutual advantage.

The *Coordinating Division on the Significance of Tests* concentrated its efforts on the development of a revised edition of the ASTM publication entitled "The Significance of Tests of Petroleum Products." The Division hopes to complete the revision this year.

The *Coordinating Division on Test Methods* is developing a recommended practice for the procedure to be followed in writing "precision" sections into the ASTM D-2 methods. The principal characteristic of the recommended practice is that "reproducibility" and "repeatability" will be determined by statistical methods based on the limits of difference between two results (range) rather than deviation from a mean. The ranges for reproducibility and repeatability will be set on a 95 per cent probability level.

Committee D-22 on Methods of Atmospheric Sampling and Analysis—Initial Meeting

OCTOBER 1 and 2 marked the effective beginning of the Society's work in atmospheric sampling and analysis, one of a number of fields into which the ASTM by request has projected itself in the past few years.

Although an organization meeting was held on January 9, 1951, and several meetings of the Executive Subcommittee were held during the year, this was the first working meeting of the committee. The more than 40 members and visitors in attendance facilitated the development of projects to be undertaken by the various subcommittees.

H. F. Hebley, in the absence of the subcommittee chairman, presented the report of Subcommittee I on Nomenclature and Units. This group set up task groups to consider:

Definitions
Abbreviations
Symbols
Units

Nomenclature and units for particulate matter as well as gases will be considered.

Subcommittee II on Methods of Sampling, under the chairmanship of Leslie Silverman, set up 5 task groups covering such topics as:

General methods of sampling
Sampling of gases and vapors
Sampling of particulate matter
Sampling for particle size
Stack rating and effluent sampling

Under consideration is the formation of a task group on miscellaneous sampling of such materials as soil, vegetation, and other sources which would have a bearing on the nature of contaminates present in the air. It was agreed that the question of bacteria should not be considered at the present time.

J. Cholak, Chairman of Subcommittee III on Analytical Methods, reported the formation of the following task groups:

Fluorides
Sulfur compounds
Nitric oxide
Particulate matter
Aldehydes
Odors

The first work of all task groups will be a literature search to evaluate present methods of analysis. This will be followed by research to provide necessary improvements or changes in present methods to warrant their publication as ASTM standards.

The work of the Instrumentation

Subcommittee (M. D. Thomas, Chairman) is divided primarily into two general classifications, aerosols, and gases. In the study of aerosols, filtration, impingement, and optical methods will be investigated. Impingement methods such as that used for sulfuric acid aerosols will be studied to determine if they can be adapted to the quantitative analysis of other types of aerosols as optical measurements depend upon the effective collection of contaminates by various types of filters. The question of filter efficiency will receive early attention. In the field of instrumentation for gas analysis, the sulfur dioxide recorder which has been used for many years appears to be sound in principle and may be used as a basis for one of the early standards. Modifications of this apparatus will be studied for possible use in the determination of total sulfur and fluoride compounds. The latter presents additional problems in view of the usually minute quantities present in the atmosphere.

The main meeting of Committee D-22 was presided over by Vice-Chairman F. S. Mallette. After approval of the By-laws, subject to confirming letter ballot of the committee, the question of toxicity was discussed. At the organization meeting, the scope of the committee had been written expressly excluding consideration of toxicity methods. It was pointed out that the scope of the committee reads "The formulation of methods of atmospheric sampling and analysis, the selection of acceptable nomenclature and definitions, and the stimulation of research to accomplish the foregoing purposes." It was agreed that toxicity limits in standards should not be considered but that Subcommittee I might wish to publish standard definitions and units in connection with toxic materials.

It was not definitely decided when the next meeting of the committee will be held, but it will be either during Committee Week or during the Annual Meeting.

Joint Federation-ASTM Committee on Paint, Varnish and Lacquer Continues to Be Active

THE personnel of this joint committee is now constituted of Messrs. R. D. Bonney, C. H. Rose, and S. Werthan representing the American Society for Testing Materials and F. M. Damitz, M. A. Claser, and M. Van Loo representing the Federation of Paint and Varnish Production Clubs.

The joint committee plans to continue expansion of its activities in fostering approval by the Federation and ASTM of standards and methods of test of mutual interest as joint standards. At the present time there are 37 ASTM and Federation standards and methods of test approved as joint standards. Six additional ASTM standards have been circulated to all Federation clubs and are ready for approval as joint standards.

In addition twelve ASTM standards specifications for selected pigments are being circulated among the Federation clubs for consideration as joint standards. To supplement this group of twelve specifications on pigments, a list of pertinent methods for chemical analysis of such pigments will also be circulated to obtain approval by the Federation as joint standards.

Special attention will be paid to advancing joint approval of recent revisions of the Methods of Testing Drying Oils (D 555 47) and the proposed method of test for viscosity of paints, varnishes, and lacquers by the Ford viscosity cup. The committee is receiving active support from D-1 Subcommittee XI on Resins in fulfilling a request from the Federation for specifications and methods of test for glycerol. The committee continues its interest in action in Subcommittee XVIII on Physical Properties on the two following Federation Standards:

9-47 Method of Permeability to Moisture of Organic Surface Coatings

10-48 Method of Test for Fineness of Dispersion of Pigmented Protective or Decorative Coatings

Following action on Subcommittee XVIII of the Proposed Method of Test for Fineness of Dispersion of Protective or Decorative Coatings, the Joint Committee will arrange for Federation consideration of this method to replace 10-48, and for eventual approval as a joint standard.

The Joint Committee will continue to function as a channel for interchange of information on technical activities in progress in both constituent organizations.

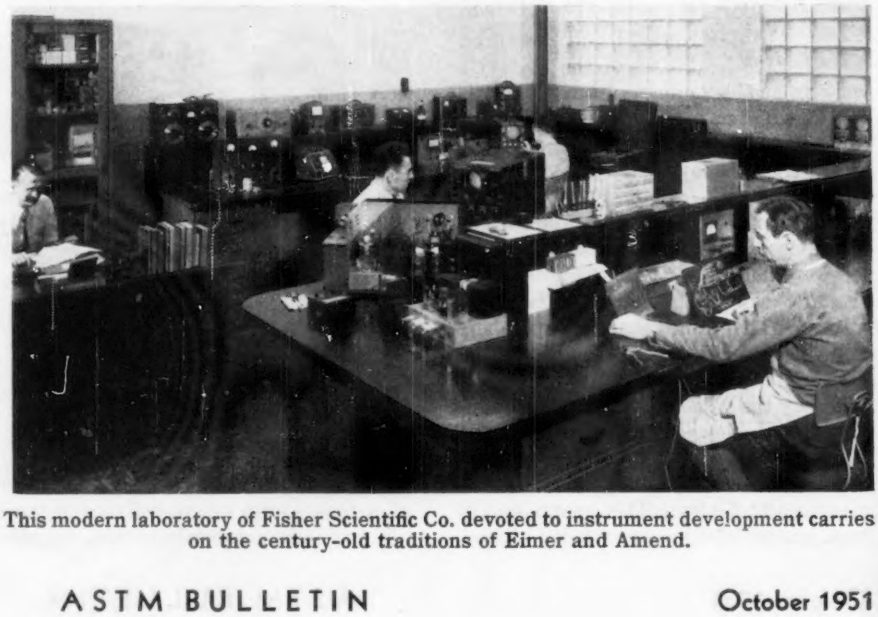
Three Centennials in Laboratory Apparatus Industry

Corning; Taylor; and Eimer & Amend, Div. of Fisher Scientific Co.—all founded in 1851—celebrate 100 years of service to industry and the nation

THE America of 1851 was stirring with expansion and transition. Railroad trackage nearly doubled in that single year. The Wabash & Erie Canal connecting the Ohio River with Lake Erie was opened. The big movement was, of course, toward the West, and there were successful settlements at the western end of the Oregon Trail. The discovery of gold in California had given recent impetus to the westward movement. In this eventful year three firms now famous in the laboratory apparatus industry were founded.

Eimer & Amend

It is highly appropriate that one of the three celebrating should be a laboratory supply house. Volume 20, No. 5, of *The Laboratory*, published by Fisher Scientific Co., is devoted to an informal history of the Eimer & Amend firm, which for the past decade has been a division of Fisher Scientific Co. The history of the firm is at the same time a history of our nation and the development of American science. Throughout the some 50 pages of informa-



This modern laboratory of Fisher Scientific Co. devoted to instrument development carries on the century-old traditions of Eimer and Amend.

Engraving of scale divisions on wax-covered industrial thermometers prior to etching with acid in a plant for Taylor Instrument Companies. Taylor produces over 275 different thermometers for industrial use, including those manufactured according to ASTM specifications. Thermometers were among the first products made by the founder George Taylor in 1851.

tive text and excellent historical cuts, these three themes are interwoven. The reader is constantly impressed with the value to the American scientist of having had at hand a laboratory supply house where a vast stock of reagents and apparatus were available for his use. Easily the most spectacular need for such facilities were the Edison experiments leading to the development of the incandescent bulb. Obviously the Edisonian or Baconian method of trying innumerable substances until the proper one for the purpose was found necessarily implied a source from which the filament materials for experiment could be obtained. Eimer & Amend was ideally set up to meet his voluminous requirements. Eimer & Amend was also able to assist Edison in the many problems associated with glass blowing (obviously an important part of his experiments), and the same "know how" was put to use in the late 90's in the production of the earliest X-ray tubes made in this country. August Eimer was the first to bring radium salts to this country for early investigators in the field of radioactivity. Again, in its role as a supplier of unusual chemicals, Eimer & Amend supplied Midgley with the antimony trifluoride for his work on the "Freon" family of refrigerants.

From the few examples noted it must be apparent that Eimer & Amend has been intimately connected with scientific advancement in America, and the publication does an excellent job of conveying this thought.

Taylor Instrument Cos.

The year 1851 saw the founding of the Taylor Instrument Cos. in Rochester, N. Y. The entire line in 1851 consisted of a few tin case thermometers, hand-carved wood-case thermometers, a water weather glass, and a few mercury barometers. Sales coverage during the 1850's was limited to the northeastern part of the country, since George Taylor personally visited all the retail outlets.

In 1866 George Taylor's younger brother Frank joined the firm which continued as a partnership until the death of George Taylor in 1889. The year 1886 saw the first fever thermometers made in the Rochester plant, and about a year later research and development began on thermometers for use in industrial plants. The turn of the century saw the beginning of an important era of expansion under the guidance of G. Elbert and J. Merton Taylor, sons of the founder George Taylor. In the period from 1877 to 1904, the Taylor catalog expanded from 6 to 266 pages and in 1905–1906 the basic industrial control equipment was developed and marketed. In 1905 Taylor brought out the now famous Type P Temperature controller and a spring-loaded pressure controller, first extensively used in the canning industry. From the 60-odd on the payroll in 1895 the Taylor company has grown to over 2000. The recent Taylor "transet TRI-ACT" controller is a highly significant addition to the already extensive line of Taylor control equipment.

The centennial issue of the Taylor house organ, *Taylor Technology*, is quite unusual in that it relates certain features of the early Taylor organization to their counterparts in the present organization. For instance, the first Taylor research department of 1885 is compared with their extensive modern program. Treated in a similar fashion are: Manufacturing facilities, quality control and inspection, skilled craftsmen, instrument markets, customer service, and products manufactured.

Corning Glass

The centennial issue of the *Corning Glass Works Gaffer* substantiates the Corning claim at the time of its centennial that the firm looks to the future rather than the past. Wishing to mark the celebration in a permanent way, the firm has erected a remarkable edifice called the "Corning Glass Center." Through its museum, library, and Steuben factory it serves to foster a better understanding of glass in the world at large. An historical section of the museum covers major examples of the glass making art down through history. Another section is devoted to the role of glass in the modern world. Various parts of the display are devoted to glass in science, research, and medicine, glass for illumination, and glass in industry. Push button controls on many exhibits permit a visitor to see how glass does its particular job.

Through its auditorium, the center provides the community of Corning with a center for such cultural activities as the theater, music, and lectures. Also provided are recreational facilities for Corning Glass employees' leisure time.

Corning Glass Center at Corning, N. Y., commemorating the company's 100 years in industry, was dedicated May 19 by New York State's Governor Thomas E. Dewey. The building features a glass museum, a library of books on glass, and a special gallery along one side of the Steuben plant permitting a visitor to view the various steps in glass manufacture.

The center was inaugurated with a three-day conference on "Living in Industrial Civilization." Taking part were 90 leaders from management, labor, government, the professions, and scholarship. The subject of the conference was suggested, according to *Corning Glass Works Gaffer*, by the Corning centennial during which the world has seen amazing changes in science, the growth of factories, cities, and towns, the rise of large business corporations, of trade unions, of new governmental activities, and new problems in human relations.

The three organizations celebrating can look back on one hundred eventful and productive years. The years ahead will certainly be as eventful.

Guidance Manual on Engineering Profession Published

A GUIDANCE manual intended for engineers who are aiding young men interested in the engineering profession was recently published by the Engineers' Council for Professional Development, New York, N. Y. The 15-page pamphlet, prepared by the ECPD Guidance Committee, urges members of local engineering societies and sections and chapters of national engineering societies to establish guidance committees to aid high-school pupils to determine whether they are qualified for careers in engineering. The present critical engineering manpower shortage emphasizes the need for guidance of the type indicated in this manual.

The manual explains briefly how to organize advisory committees and how to select committee members. The manual contains suggestions for working with high schools and secondary school students and lists aids especially useful in counseling high-school boys. Copies of the manual with questionnaire may be obtained from ECPD, 29 West 39th St., New York 18, N. Y. Price of combination is 20 cents.

The ECPD is a conference of engineering bodies organized to advance the engineer professionally through the cooperative support of its national organizations directly representing the professional, scientific, educational, and legislative phases of the engineer's life.

Book Review

Theory of Flow and Fracture of Solids—Vol. I

THE present volume by A. Nadai, Consulting Mechanical Engineer to Westinghouse Research Laboratories, is an enlargement and revision of his well-known "Plasticity." The volume contains three parts, totaling 37 chapters. The author in his introduction states that it is not his intention to delve into the metallurgical or physical aspects of the solid state as related to atomic mechanisms or structures, but to treat plastic flow from the viewpoint of the methods of mechanics and mathematics.

Part I of the book deals with "Deformation of Solids—Analysis of Stress and Strain," the initial section of which covers briefly among other things fluid and solid states, elastic, viscous, and plastic substances, polymorphism, ordered and unordered states of matter, crystalline structure in metals, and mechanism of plastic deformation in grain structure. It is this writer's belief that these topics cannot be comprehensively treated without delving in a large degree into the physical, metallurgical, and atomic structure aspects. As a consequence, the new reader may be forced to ground himself in these topics from other sources. Included in this part is a large amount of experimental evidence which will be of great value to the experienced reader, but which may be only confusing to the beginner not equipped with some physical or metallurgical background.

Following this in Part I is a very fine and very thorough presentation of the geometry of stress and strain (including finite strains), upon which the author is to be complimented. Special note is made of Chapter 14 in which the author considers the vector geometry of stress and strain, vector fields, and tensors. Here he decries the increasing use of the tensor notation as being unnecessary in the consideration of stress and strain. The author may well have a point here, inasmuch as the average practicing engineer is not usually familiar with tensors. The author, in the same chapter, however, introduces the Gibbs mathematics of dyadics, a notation even less known among engineers, and probably not nearly as useful as tensors.

Part II deals with "The Yielding of Solids, Particularly of the Metals Under Simple States of Stress." Flow and fracture criteria under combined stresses are presented. There is much accompanying experimental data, ably discussed. Part II is concluded with certain special topics such as plastic torsion of a round bar, bending of bars, and plastic buckling.

Part III covers "The Elastic, the Very Viscous, the Ideally Plastic Substance, and Some of Their Generalizations." The chapters contain discussions of stress-strain and strain rate relations of elastic, plastic, viscous, and visco-plastic solids. The treatment is entirely from the mathematical point of view, which for instance, in such a topic as the theory of strain hardening of metals may very well describe the phenomenon. Mathematical treatment alone, however, cannot serve to explain the phenomenon. Part II concludes with a presentation of various boundary value problems such as rotational symmetry, general torsion, etc.

The general scope of the book is set forth in the author's introduction, as are the limitations. It is the opinion of this reviewer that for good understanding, the phenomenological happenings of plastically strained solids cannot be separated from metallurgical, physical, and atomic concepts. In this sense, the theory of flow and fracture of solids is incomplete when only mathematical and mechanical considerations are fully presented. It must be stated, however, that for engineering applications, the book is undoubtedly the finest in its field. A great mass of experimental evidence is fully discussed, with listings of appropriate references. Anyone starting to work in the field of engineering plasticity will start with this volume.

Copies of the 572-page book can be obtained from McGraw-Hill Book Co., 330 W. 42d St., New York, N. Y., at $10 per copy.

M. E. SHANK

Paint Film Defects—Their Causes and Cure

WITH approximately 7000 possible causes for paint difficulties, the coatings technologist—be he formulator, salesman, or developer of new raw materials—will welcome a handy reference book, the first of its kind to come to this reviewer's attention. This publication by Manfred Hess entitled "Paint Film Defects—Their Causes and Cure," is a logical compilation and arrangement of remarkable scope.

Starting with four major classes: (1) in the can, (2) during application, (3) shortly after applied, or (4) during long-time service, the author has selected 124 major divisions for his treatment. Each section has many subdivisions, the number depending on the individual methods causing that particular paint defect. While little of the material presented is new or original, the author is generous in his acknowledgment of the assistance of others and provides appropriate references to the technical literature that has served as his sources of information. The original part is that the information has been gathered together under one cover and in a neat and concise manner.

On the less favorable side, the book is done in the English style as to spelling and numerical indexing. A majority of the references are European and English. The material is often not as up to date as is possible or as desired. In spite of the shortcomings, the book should serve as an admirable reference book, encyclopedia, and dictionary not only for the newcomer, but to the "trouble shooter" and to the new product development man as well.

The 544-page publication can be obtained through Chapman & Hall, Ltd., 37 Essex St., London W.L.2, England, at 50*s*. per copy.

H. GRINSFELDER

High-Calcium Limestone

A WEALTH of information is presented in a 105-page publication just released by The Baltimore & Ohio Railroad on the subject of high-calcium limestone. This is in the nature of a report by states which are served by the B&O Railroad, each report presenting descriptions, figures, maps, and tables on the important high-calcium formations and deposits in that particular area.

An extensive bibliography is included representing references from which portions of the report were prepared, state and geological survey organizations being

the primary sources of information. The interpretation of data largely has been that of the author—John A. Ames, Industrial Geologist of the B&O.

The appendices include data of a more abstract or technical nature and include sections on pertinent geology of limestone and comments on production, high-calcium limestone uses, summary of stratigraphy, and a glossary of terms. Questions or requests pertaining to this publication may be referred to the Manager Industrial Development, Traffic Department, The Baltimore & Ohio Railroad Co., Baltimore 1, Md.

Revised Edition of Chicago Building Code Book Announced

A NEW edition of "Chicago Building Code and Index" is now being prepared for publication to give effect to the complete revision of the Chicago electrical ordinances and to a number of changes in the building chapters.

The new edition is priced at $3.50 per copy and contains a cross-index to chapters and paragraphs of the regulations. The edition is published by Index Publishing Corp., 40 N. Wells St., Chicago 6, Ill.

ASHVE Environment Laboratory in Cleveland to Be Inaugurated with Two-Day Inspection, November 1–2

A TWO-DAY reception and inspection for executives, society members, and the press will be held by The American Society of Heating and Ventilating Engineers in Cleveland, November 1–2, to mark the completion of its Environment Laboratory, a facility for research in human comfort conditions and the development of data for the design and installation of panel heating and cooling systems.

The Environment Laboratory, the newest and perhaps the most important of the ASHVE's facilities for fundamental research, is the society's answer to the belief that there is a lack of authentic and universal design data for panel heating and cooling installations. Early in 1947 more than 100 representative engineers from consulting firms, technical societies, government agencies, universities, trade associations, and industry attended a general conference in Cleveland to discuss this situation.

It was the consensus of opinion at the meeting that the ASHVE should coordinate the program of developing, through research, adequate design data in this field. Later in 1947 a Technical Advisory Committee on Panel Heating and Cooling was formed by the Committee on Research to direct over-all technical activities for the research program.

An over-all program developed, subdivided the general research problem into four spheres of activity:

1. Heat distribution within and behind the panel.
2. Heat transfer between the panel and the space.
3. Comfort conditions.
4. Controls.

It became apparent that, in order to implement these activities (heat transfer between the panel and the space), it would be necessary to construct a full-sized room of dimensions comparable to those encountered in building construction wherein all the room surfaces (and portions of each surface) were separately controllable as to surface temperature so that calorimeter studies could be made under varying surface temperature conditions.

The room, as constructed, occupies an interior area of about 25 ft long and 12 ft wide with an adjustable ceiling providing heights up to 12 ft. The room is designed so that it can be subdivided when desired into two rooms.

American Association for the Advancement of Science Plans Annual Meeting

SECTION "M"—Engineering of the American Association for the Advancement of Science has announced tentative plans for the annual meeting to be held in Philadelphia, Pa., Dec. 26–31, 1951. It is expected that the meeting will be held jointly with various local technical societies. For further detail write to the Secretary of Section "M"—Engineering, Frank D. Carvin, Illinois Institute of Technology, Technology Center, Chicago 16, Ill.

About Books

Excerpted from "The Public Library: Rampart for Freedom" by Luther H. Evans, Librarian of the Library of Congress—Saturday Review of Literature, July 7, 1951.

Even the smallest organization can still afford to publish a book or pamphlet. Both the specialized learned institution and the small committee with a "cause" find in the book their means of expression.

Moreover, books are the only general medium of communication under the control of the recipient. A man who wants to experience "Hamlet" may have to wait months or even years before he has a chance to see it on the screen or stage or television or hear it over the ratio; but he can read it when he chooses. Though the educational potentialities of the other media are enormous, it is only by rare coincidence that a man impelled to find out something about nuclear fission or cancer control will be able to tune in on a program that will answer his questions; but if he has access to a good collection of books he can get immediately what he wants.

Emergency Alternate Provisions Issued Affecting Steel Plates, Sheets, Tubes, Bars and Pipes

IN LINE with the procedures for establishing Emergency Alternate Provisions, a number of Emergency Alternates have been issued on the recommendations of several of the technical committees. They are also being printed in the form of "pink" slips and a copy of each Emergency Alternate can be procured by members on request.

EA–A 26

Issued August 21, 1951

The following Emergency Alternate Provisions, when specified, may be used as an alternate in ASTM Standard Specifications for Steel Tires (A 26 – 39) and affect only the requirements referred to:

Section 4.—For acid steel only, change the requirements for maximum phosphorus and sulfur contents from the present "0.05" to read "0.06" per cent.

Section 5.—Add at the end of the last sentence "except that, for acid steel only, the maximum phosphorus and sulfur contents shall be 0.06 per cent."

Section 6.—Add at the end of the last sentence the same phrase as indicated above for Section 5.

EA–A 167

Issued August 21, 1951

The following Emergency Alternate Provisions, when specified, may be used as an alternate in ASTM Standard Specifications for Corrosion-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip (A 167 – 44) and affect only the requirements referred to:

Table I.—In view of the limited availability of columbium (with the heretofore usual small percentage of tantalum) the stabilizing addition to grade 6 (type 347) shall consist of columbium plus tantalum. The ratio of columbium to tantalum (in relation to the carbon content of the steel) and the maximum of each element, or of one of them, or of the two combined, shall be determined in accordance with the requirements of the end use and shall be as mutually agreed upon by producer and purchaser.

EA–A 240

Issued August 21, 1951

The following Emergency Alternate Provisions, when specified, may be used as an alternate in ASTM Standard Specifications for Corrosion-Resisting Chromium and Chromium-Nickel Steel Plate, Sheet, and Strip for Fusion-Welded Unfired Pressure Vessels (A 240 – 49) and affect only the requirements referred to:

Table I.—In view of the limited availability of columbium (with the heretofore usual small percentage of tantalum) the stabilizing addition to grade C, (type 347 modified) shall consist of columbium plus tantalum. The ratio of columbium to tantalum (in relation to the carbon content of the steel) and the maximum of each element, or one of them, or of the two combined, shall be determined in accordance with the requirements of the end use and shall be as mutually agreed upon by producer and purchaser.

EA-A 269

Issued October 18, 1951

The following Emergency Alternate Provisions, when specified, may be used as an alternate in ASTM Standard Specifications for Seamless and Welded Austenitic Stainless Steel Tubing for General Service (A 269 – 47) and affect only the requirements referred to:

Table I.—In view of the limited availability of columbium (with the heretofore usual small percentage of tantalum) the stabilizing addition to grade TP 347 shall consist of columbium plus tantalum. The ratio of columbium to tantalum (in relation to the carbon content of the steel) and the maximum of each element, or of one of them, or of the two combined, shall be determined in accordance with the requirements of the end use and shall be as mutually agreed upon by producer and purchaser.

EA-A 271

Issued October 18, 1951

The following Emergency Alternate Provisions, when specified, may be used as an alternate in ASTM Standard Specifications for Seamless Austenitic Chromium-Nickel Steel Still Tubes for Refinery Service (A 271 – 47) and affect only the requirements referred to:

Table I.—In view of the limited availability of columbium (with the heretofore usual small percentage of tantalum) the stabilizing addition to grade TP 347 shall consist of columbium plus tantalum. The ratio of columbium to tantalum (in relation to the carbon content of the steel) and the maximum of each element, or of one of them, or of the two combined, shall be determined in accordance with the requirements of the end use and shall be as mutually agreed upon by producer and purchaser.

EA-A 276

Issued August 21, 1951

The following Emergency Alternate Provisions, when specified, may be used as an alternate in ASTM Tentative Specifications for Hot-Rolled and Cold-Finished Corrosion-Resisting Steel Bars (A 276 – 49 T) and affect only the requirements referred to:

Table I.—In view of the limited availability of columbium (with the heretofore usual small percentage of tantalum) the stabilizing addition to type 347 shall consist of columbium plus tantalum. The ratio of columbium to tantalum (in relation to the carbon content of the steel) and the maximum of each element, or one of them, or of the two combined, shall be determined in accordance with the requirements of the end use and shall be as mutually agreed upon by producer and purchaser.

EA-A 296

Issued August 21, 1951

The following Emergency Alternate Provisions, when specified, may be used as an alternate in ASTM Tentative Specifications for Corrosion-Resistant Iron-Chromium and Iron-Chromium-Nickel Alloy Castings for General Application (A 296 – 49 T) and affect only the requirements referred to:

Table II.—In view of the limited availability of columbium (with the heretofore usual small percentage of tantalum) the stabilizing addition to grade CF-8C shall consist of columbium plus tantalum. The ratio of columbium to tantalum (in relation to the carbon content of the steel) and the maximum of each element, or of one of them, or of the two combined, shall be determined in accordance with the requirements of the end use and shall be as mutually agreed upon by producer and purchaser.

EA-A 312

Issued October 18, 1951

The following Emergency Alternate Provisions, when specified, may be used as an alternate in ASTM Tentative Specifications for Seamless and Welded Austenitic Stainless Steel Pipe (A 312 – 51 T) and affect only the requirements referred to:

Table I.—In view of the limited availability of columbium (with the heretofore usual small percentage of tantalum) the stabilizing addition to grade TP 347 shall consist of columbium plus tantalum. The ratio of columbium to tantalum (in relation to the carbon content of the steel) and the maximum of each element, or of one of them, or of the two combined, shall be determined in accordance with the requirements of the end use and shall be as mutually agreed upon by producer and purchaser.

EA-A 314

Issued August 21, 1951

The following Emergency Alternate Provisions, when specified, may be used as an alternate in ASTM Tentative Specifications for Corrosion-Resisting Steel Billets and Bars for Reforging (A 314 – 47 T) and affect only the requirements referred to:

Table I.—In view of the limited availability of columbium (with the heretofore usual small percentage of tantalum) the stabilizing addition to grade TP 347 shall consist of columbium plus tantalum. The ratio of columbium to tantalum (in relation to the carbon content of the steel) and the maximum of each element, or of one of them, or of the two combined, shall be determined in accordance with the requirements of the end use and shall be as mutually agreed upon by producer and purchaser.

EA-A 329

Issued August 21, 1951

The following Emergency Alternative Provisions, when specified, may be used as an alternate in ASTM Tentative Specifications for Heat-Treated Steel Tires (A 329 – 50 T) and affect only the requirements referred to:

Section 6.—Revise to read as follows by the addition of the italicized words and figures: "The steel shall conform to the requirements for chemical composition prescribed in Table I, *except the required manganese content range shall be 0.50 to 0.90 per cent, and, for acid steel only, the maximum phosphorus and sulfur contents shall be 0.06 per cent.*"

Table I.—Change the required manganese content range from the present "0.60 to 0.90" to read "0.50 to 0.90" per cent.

For acid steel only, change the requirements for maximum phosphorus and sulfur contents from the present "0.05" to read "0.06" per cent.

Section 7.—Revise the third sentence to read as follows by the addition of the italicized words and figures: "The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements prescribed in Table I, *with the exception that the required manganese range shall be 0.50 to 0.90 per cent and, for acid steel only, the maximum phosphorus and sulfur contents shall be 0.06 per cent.*"

Section 8.—Revise the second sentence to read as follows by the addition of the italicized words and figures: "The chemical composition thus determined shall not vary from the requirements prescribed in Table I, *with the exception that the required manganese range shall be 0.50 to 0.90 per cent, and for acid steel only the maximum phosphorus and sulfur contents shall be 0.06 per cent,* by more than the amounts prescribed in Table II."

PERSONALS...

News items concerning the activities of our members will be welcomed for inclusion in this column.

NOTE—*These "Personals" are arranged in order of alphabetical sequence of the names. Frequently two or more members may be referred to in the same note, in which case the first one named is used as a key letter. It is believed that this arrangement will facilitate reference to the news about members.*

At its Louisville meeting the Board of Direction of the American Society of Civil Engineers elected to honorary membership the following engineers outstanding in their fields of specialization: **Samuel A. Greeley, Jonathan Jones,** and **Frederick Ohrt,** all three active also in ASTM work. Mr. Greeley, an authority in the sanitary engineering field, is senior partner in the Chicago consulting firm of Greeley & Hansen. Jonathan Jones, Chief Engineer of Fabricated Steel Construction for the Bethlehem Steel Co. since 1931, has had a long career of achievement with the Bethlehem Co. and its predecessor organization, the McClintic-Marshall Co. Frederick Ohrt, as Manager and Chief Engineer of the Board of Water Supply of the City and County of Honolulu since 1929, has initiated broad-scale research work and has been responsible for the engineering of extensive ground-water development construction. Honorary Membership awards will be made on October 24 during the Annual Convention of ASCE in New York City.

R. C. Allen, formerly Manager and Chief Engineer, Turbo-Power Development Dept., Allis-Chalmers Mfg. Co., Milwaukee, Wis., has been appointed Consulting Engineer of the General Machine Division of his company.

Bani R. Banerjee, for some time associated with the Bengal Engineering College in India, has returned to the staff of the Standard Oil Co. (Ind.), Chicago, Ill., in the capacity of Research Metallurgist.

Paul A. Beck, formerly Associate Professor of Metallurgy, University of Notre Dame, is now Research Professor of Metallurgy, University of Illinois, Urbana.

Richard A. Biggs, until recently Director, Architectural Development, Stainless Steel Div., Crucible Steel Co. of America, has been named Director of Development, Franki Foundation Co., New York City.

Robert F. Blanks, for many years associated with the U. S. Bureau of Reclamation, Denver, Colo., more recently in the Division of Engineering Control and Research, is now Vice-President and General Manager, Great Western Aggregates, Inc., in the same city. He has been active in ASTM committees and has made many contributions to our work.

W. E. Elwell has been appointed Manager of Eastern Products Development, Oronite Chemical Co., New York City. He was formerly Supervisor of Chemical Products for California Research Corp.

Edward Epremian is now Scientific Liaison Officer, Office of Naval Research, London Branch, Schenectady, N. Y. He was previously Research Metallurgist, Carnegie Institute of Technology, Pittsburgh, Pa.

Jean E. Hittle, formerly Research Engineer, Colorado State Highway Dept., Denver, is now with the New Mexico State Highway Materials Dept., Albuquerque, in the capacity of Materials Engineer.

Robert W. Hunt Co., Engineers, Chicago, Ill., wish to announce that W. H. Bolger has advanced to Manager of Laboratories, and Cromwell Bowen to Assistant Manager of Laboratories.

George T. Jones, formerly Assistant Metallurgical Engineer, has been appointed Metallurgical Engineer, Railroad Materials and Forgings, United States Steel Corp., Pittsburgh, Pa. **Carl W. Tuttle** has been named Assistant Metallurgical Engineer, in the same Pittsburgh department; and **James R. Hamilton** replaces Mr. Tuttle as Senior Service Metallurgist, Railroad Materials and Forgings, in the Company's Chicago office.

Louis Kahn, Director of Research, Aerovox Corp., New Bedford, Mass., and Director of Aerovox Canada, Ltd., has been appointed expert consultant on components, Panel of Components, and also Chairman of the Capacitor Sub-panel, Research and Development Board for the Armed Forces.

Charles F. Kettering, retired Vice-President, and presently Director and Consultant, General Motors Corp., Detroit, Mich., celebrated his 75th birthday on August 29. Among celebrations in his honor was an exposition in Dayton, Ohio, dedicated to his contributions to America's progress. Dayton claims him as an adopted son, since he moved there in 1904 to begin his fabulous career with a job at National Cash Register, his first important invention having been an automatic cash register. Just 40 years ago the first car with the Kettering ignition system and self-starter appeared. On display at the Dayton exposition were early model automobiles, a cancer display, a small-scale model diesel locomotive, a baby incubator, parts of the first aerial torpedo, fever machines, and hundreds of other things which Mr. Kettering helped to make. A member of ASTM since 1915, he has participated in many of the Society's activities.

Keith B. Kettle, formerly Heating Engineer, Fairbanks, Morse & Co., Three Rivers, Mich., is now associated with Hotpoint, Inc., Chicago, Ill., in the capacity of Changes Engineer.

Harold Lutes, General Manager, Layrite Concrete Products Co., Spokane, Wash., and retiring President of the Concrete Products Association of Washington, has been elected a Director of the Association for the coming year.

T. W. Merrill recently was appointed Chief Metallurgical Engineer of Vanadium Corp. of America, transferring from the plant at Bridgeville, Pa., to executive offices in New York City. Among Mr. Merrill's activities in ASTM particular note might be made of his contribution as Secretary of Subcommittee VI on Steel Forgings and Billets of Committee A-1 on Steel, which group during the past few years has had a most active program. At the June meetings of Committee A-1 he was appointed a member of its Advisory Committee, in recognition of his active work in the committee.

Rockwell Newman, President, Rockwell Newman Co., Orange, N. J., attended a Building Congress in London in September, traveling enroute on the same boat as ASTM Executive Secretary **C. L. Warwick** who is now in Europe in the interest of the Society.

Hubert C. Normile, a former Veterans Administration chemist, now with the Department of the Army, has been given a $600 efficiency award by the Veterans Administration for developing a process that prevents wool blankets from shrinking while being laundered.

On August 31, **Howard S. Phelps,** for a number of years Engineer in Charge of the Testing Division, Philadelphia Electric Co., retired from his duties with that company, and at the same time relinquished his representation of the company's Sustaining Membership in ASTM. Both in the company and in its representation in ASTM he is succeeded by **Harold A. Dambly.** Mr. Phelps has been very active in the Society, not only in technical committees, such as B-2 on Non-Ferrous Metals and Alloys, B-3 on Corrosion of Non-Ferrous Metals and Alloys, and D-9 on Electrical Insulating Materials, but for several years in the Philadelphia District Council. For the last three years, among his other assignments for the District has been the responsibility for certain technical programs and the development of the very interesting ladies' entertainment programs for the last three Annual Meetings in Atlantic City. He will continue to reside at No. 3 E. Turnbull Ave., Havertown, Pa.

Gerald Pickett, formerly on the faculty of the Kansas State College of Agriculture and Applied Science, Manhattan, is now Professor of Mechanics, University of Wisconsin, Madison.

Charles F. Pogacar, until recently Metallurgical Engineer, Koppers Co., Inc., Pittsburgh, Pa., is now associated with the Atlantic Refining Co., Philadelphia, in a similar capacity.

Glenn E. Rolston, Vice-President and Director of Sales, Rome Cable Corp., Rome, N. Y., has been appointed Chief of the Wire and Cable Branch, Metal and Minerals Bureau, Copper Division, National Production Authority, Washington, D. C.

Harry G. Romig, Staff Engineer, Hughes Aircraft Co., Culver City, Calif., also Staff Engineer, American Society for Quality Control, New York City, is giving a course in Quality Control at the University of California, Los Angeles, under he Extension Division of Engineering, using as one of the required texts the ASTM Manual on Quality Control of Materials.

Hervey Judson Skinner, formerly associated with Skinner & Sherman, Inc., Boston, Mass., is now Treasurer, American Conditioning House, Inc., in the same city.

Charles B. Thompson, until recently on the faculty of the University of New Mexico Department of Civil Engineering has accepted an appointment in the State Engineer's Office, Santa Fe, N. Mex.

E. F. Tibbetts, formerly Metallurgical Engineer, The Lummus Co., New York City, is now on the technical staff of the Wollaston Brass & Aluminum Foundry, North Quincy, Mass. Mr. Tibbetts, who has represented The Lummus Co. in the Society and on a number of the technical committees for several years, will continue his ASTM affiliation through a personal membership. He will be succeeded in The Lummus Co. by **E. J. Vanderman,** who also will carry on the representation of this company in the Society.

NEW MEMBERS . . .

The following 56 members were elected from August 14, 1951, to September 24, 1951, making the total membership 7044 . . . Welcome to ASTM

Note—Names are arranged alphabetically—company members first, then individuals

Chicago District

CAMP CO., INC., THE, Sam Camp, President, 6958 S. State St., Chicago 21, Ill.

HAMILTON, JAMES R., Senior Service Metallurgist, Railroad Materials and Forgings, United States Steel Co., 208 S. LaSalle St., Chicago 90, Ill.

LANCASTER, GEORGE H., Chief Engineer, Fuels and Lubricants Section, I.P.E.D., International Harvester Co., Advanced Engineering Group, Industrial Power Div., Melrose Park, Ill.

PESSES, MARVIN, Metallurgical Engineer, Alter Co., 1701 Rockingham Rd., Davenport, Iowa. [J]*

SCHNITZ, H. A., Engineer of Tests, Chicago Rock Island & Pacific Railroad Co., 4701 Wentworth Ave., Chicago 9, Ill.

TICHENOR, NORMAN B., Vice-President in Charge of Sales, Prairie States Oil and Grease Co., Box 856, Danville, Ill.

Cleveland District

BENDIX-WESTINGHOUSE AUTOMOTIVE AIR BRAKE CO., S. Johnson, Jr., Chief Engineer, 901 Cleveland Rd., Elyria, Ohio.

TREMCO MANUFACTURING CO., THE, Gordon E. Hann, Vice-President, Research and Production, 8701 Kinsman Rd., Cleveland 4, Ohio.

ERF, HERBERT A., President, The H. A. Erf Acoustical Co., 3868 Carnegie Ave., Cleveland 15, Ohio.

GILBERT, LAWRENCE L., Chief Metallurgist, The Oliver Corp., 19300 Euclid Ave., Cleveland 17, Ohio. For mail: 3766 Grosvenor Rd., South Euclid 18, Ohio.

RUSS, JAMES J., Chief Metallurgist, The Steel Improvement and Forge Co., Cleveland, Ohio. For mail: 970 E. Sixty-fourth St., Cleveland 3, Ohio.

Detroit District

LAKEY FOUNDRY AND MACHINE CO., Wilbur A. Hallberg, Chief Metallurgist, Muskegon, Mich.

LEAR, INC., Fred Boshoven, Standards Engineer, 110 Ionia Ave., N. W., Grand Rapids 2, Mich.

WAYNE UNIVERSITY, COLLEGE OF ENGINEERING, A. R. Carr, Dean, 5140 Second Ave., Detroit 2, Mich.

New England District

JENKINS, GEORGE A., Engineer of Technical Service, Warren Brothers Co., 38 Memorial Dr., Cambridge 42, Mass

New York District

BEAMISH, BERNARD DELACOUR, Vice-President, Treasurer, and Director, Honeycomb Company of America, Inc., 22 W. First St., Mount Vernon, N. Y.

HOWICK, E. G., Assistant General Manager, Suburban Propane Gas Corp., Whippany, N. J.

KOEHLER, HENRY C., Plant Engineer, Koehler Instrument Co., 168-56 Douglas Ave., Jamaica, N. Y. For mail: 271-24 Seventy-seventh Ave., New Hyde Park, N. Y. [J]

LEONARD, EDMUND A., Manager, Technical Laboratory Div., Alexander Smith, Inc., Yonkers 1, N. Y.

MOHLING, GUNTHER, Assistant Director of Research, Allegheny Ludlum Steel Corp., Watervliet, N. Y.

NAZZARO, R. M., President and Chief Chemist, American Textile Processing Co., 18 Market St., Paterson 1, N. J.

OLIPHANT, WILLIAM T. J., Sales Manager, Patent Chemicals, Inc., 335 McLean Blvd., Paterson 4, N. J. For mail: 5 Park St., Bloomfield, N. J.

ORELUP, JOHN W., President, Patent Chemicals, Inc., 335 McLean Blvd., Paterson, N. J.

PEACOCK, PAUL E., JR., Owner, Box 268, Westfield, N. J.

PETTIT, JAMES A., JR., In Charge of Inspection Dept., Standard Cable Corp., Chickasha, Okla. For mail: 97-30 108th St., Richmond Hill 19, N. Y.

SCHAEFFER, EMIL, Chief Engineer, Tower Div., Elizabeth Iron Works, Inc., Box 360, Elizabeth, N. J. For mail: 530 Vine St., Elizabeth 2, N. J.

ZIMMERMAN, PERCY W. Boyce Thompson Institute for Plant Research, Inc., Yonkers 3, N. Y.

ZINO, ANTHONY J., JR., Assistant to President, Swan-Finch Oil Corp., RCA Bldg., West, New York, N. Y. For mail: 27 Shoreview Rd., Manhasset, L. I., N. Y.

Ohio Valley District

ADAMS, HAROLD W., Product Supervisor, Cable, Reynolds Metals Co., 2500 S. Third St., Louisville 1, Ky.

DUGGER, EDWARD, Materials Engineer, Wright Air Development Center, United States Air Force, Research Div., Wright Patterson Air Force Base, Dayton, Ohio. For mail: 1616 Roosevelt Ave., Dayton 8, Ohio.

SWAN, VERNON, Ingot Product Supervisor, Reynolds Metals Co., 2500 S. Third St., Louisville, Ky.

WALLACE, CHARLES THOMAS, Superintendent of Coal Preparation, The Elk Horn Coal Corp., Inc., Wayland, Ky.

Philadelphia District

FIRESTONE TIRE AND RUBBER CO., B. K. Lyckberg, Manager, Plastics Labs., Box 690, Pottstown, Pa.

KING, ALFRED S., Process Engineer, Houdry Process Corp., 1528 Walnut St., Philadelphia, Pa. For mail: Box 623, Bryn Mawr, Pa.

Pittsburgh District

SPEAKER, C. A., Chemist, A. M. Byers Co., Ambridge, Pa.

St. Louis District

JOHNSON, BURT, Cotton Technologist, National Cotton Council of America, Box 18, Memphis, Tenn.

ROGERS, L. N., Director of Research, The Buckeye Cotton Oil Co., 2899 Jackson Ave., Memphis 1, Tenn.

Washington (D. C.) District

CALLENDER, A. B., Supervisor, Structures Test Lab., The Glenn L. Martin Co., Baltimore 3, Md.

CRIPPEN, RAYMOND C., Head and Owner, Crippen Research and Development Laboratories, Fleet St. and Central Ave., Baltimore 2, Md.

LOCRAFT, BERNARD F., Civil Engineer, 1179 New Hampshire Ave., N. W., Washington 7, D. C.

SACHERS, G. ERIC, Resident Engineer, Associated Housing Consultants, 124 W. Church Ave., Roanoke, Va. For mail: Box 1885, Roanoke 8, Va.

WILSON, WILLIAM K., Chemist, National Bureau of Standards, Washington 25, D. C.

Western New York-Ontario District

GOOSE, ERNEST, Assistant Chemist, Scarfe and Co., Ltd., Brantford, Ont., Canada. For mail: Box 861, Paris, Ont., Canada.

U. S. and Possessions

ALLEN, DWIGHT M., Inspection Engineer, McNamar Boiler and Tank Manufacturing Co., N. Rockford and Frisco Railroad, Tulsa, Okla. [J]

ELLSPERMAN, LEWIS M., Materials Engineer, Bituminous Lab., U. S. Bureau of Reclamation, Denver, Colo. For mail: 3749 Quitman St., Denver 3, Colo.

EVANS, DWIGHT J., Consulting Engineer, Room 1107, 910 S. Boston, Tulsa 3, Okla.

HOSTICKA, HAROLD E., Physicist, U. S. Bureau of Reclamation, Bldg. 1B, Denver Federal Center, Denver, Colo. For mail: 2510 Harlan Blvd., Denver 14, Colo.

SHIRLEY, CHARLES E., Director, Materials Testing Div., U. S. Department of the Navy, Commander Naval Forces Marianas, Box 532, Agana, Guam.

Other than U. S. Possessions

VEREIN DEUTSCHER PORTLAND-UND HUTTENZEMENTWERKE E.V., Fritz Keil, Eckstrasse 17, Dusseldorf (U. S. Zone), Germany.

GOVERNMENT CHEMICAL LABORATORIES, Director, Adelaide Terrace, Perth, Western Australia.

PAES, ANTONIO, Assistant Production Manager, Ceramic Div., Cia. Brasileira de Vidros, Rio de Janeiro, Brazil. For mail: Rua Coracao de Maria 247 Meyer, Rio de Janeiro, Brazil.

SAUNDERS, S. L. M., Director of Research, Pinchin, Johnson and Associates, Ltd., Minerva Works, North Woolwich Rd., Silvertown E.16, England.

SONI, S. L., Chemist, Shree Digvijay Cement Co., Ltd., Seeka, Jamnagar, India.

TUPINAMBA, HAROLDO DART, Production

Manager of Chinaware Div., Cia. Brasileira de Vidros, Rio de Janeiro, Brazil. For mail: Rua Professor Gabizo, n° 144, Rio de Janeiro, Brazil.

VAN DER GRAAF, J., Director, N. V. Metallic Industry, 80 Groest, Hilversum, The Netherlands.

WHITE, E. G., City Chemist, Johannesburg City Council Laboratory, Box 1477, Johannesburg, South Africa.

* [J] denotes Junior Member.

NECROLOGY...

The death of the following members has been reported

CHARLES HAYDOCK, Consulting Engineer, Philadelphia, Pa. (Aug. 31, 1951). Member since 1927. Active for many years in the work of Committee A-3 on Cast Iron, and Committee D-19 on Industrial Water; also a member of the Philadelphia District Council.

EDWIN L. HETTINGER, Director of Optical Research, Willson Products, Inc., Reading, Pa. (Sept. 2, 1951). Member since 1929. A specialist in the industrial applications of glass as an eye protective material, Mr. Hettinger was one of the pioneers in the development of the modern safety goggle; he also had contributed to research on glass formulas providing cut-off of ultraviolet and infrared rays, resulting in the development of protective tinted glass. In addition to ASTM, his society affiliations included The American Ceramic Society, American Chemical Society, Optical Society of America, and the British Society of Glass Technology. His hobby was photography, and he helped form the Reading Camera Club. He had participated actively in some of the earlier ASTM Photographic Exhibits.

ROBERT JOB, retired Vice-President, Milton Hersey Co., Ltd., Westmount, Que., Canada (June 22, 1951). Member since 1900. Born in 1866, Mr. Job was a leader in the field of industrial chemistry for over a half-century. In his very early years he had been Chemist for the Philadelphia and Reading Ry., and for some years prior to joining the staff of the Hersey Laboratories in 1910, had been a member of the firm of Booth, Garrett and Blair, Chemists, Philadelphia. He also served through the years as chemist for various railroads. In ASTM he rendered important service both in technical and administrative committees. He had served on several of the ferrous groups for long periods, and had been a member of Committee D-1 on Paint, and Committee D-3 on Chemical Analysis of Metals. He was a Past Director of ASTM, and at the June, 1950, Annual Meeting of the Society was elected to Honorary Membership. In addition to ASTM affiliation he was a member of a number of other societies, his membership in the American Chemical Society dating from 1894.

ASA H. NUCKOLLS, formerly Chemical Engineer of Underwriters' Laboratories, Inc., Chicago, Ill. (Aug. 31, 1951). For many years representative of company membership, rendering service on a number of ASTM technical committees.

F. E. TURNEAURE, Emeritus Dean, College of Mechanics and Engineering, University of Wisconsin, Madison (March 31, 1951). Affiliated with the Society since 1902, Dean Turneaure was a member of the Board of Directors 1916–1918, and had rendered valued service for many years on former ASTM Committees C-2 on Reinforced Concrete, and C-6 on Drain Tile, serving as Chairman of the former group. He also had taken active part in the deliberations of the Joint Committee on Concrete and Reinforced Concrete, contributing a number of papers in this field.

HERVEY S. VASSAR (retired), Laboratory Engineer, Public Electric and Gas Co., Maplewood, N. J. (Aug. 30, 1951). Member since 1915. (See accompanying article.)

Hervey Sackett Vassar 1877–1951

ON SATURDAY afternoon, September 1, the pastor of the Central Baptist Church in East Orange, N. J., who had known Hervey S. Vassar for over 20 years, paid a moving tribute to this ASTM Past-President and Honorary Member, for his genuine interest in the welfare of his friends and associates. "He labored for the common good" was the general theme of the remarks. All those who knew Mr. Vassar would agree wholeheartedly.

Immediately upon his graduation in 1903 from Pratt Institute, Brooklyn, where he majored in applied electricity, Mr. Vassar became associated with the Public Electric and Gas Co., Maplewood, N. J. He spent his entire business career with this company, assuming the position of Laboratory Engineer (in charge of all electrical, mechanical, and materials testing) in 1911, and retiring from active duties in 1948.

In the Society, Mr. Vassar had served faithfully and very constructively for many years, and in recognition of his outstanding contributions ASTM had given him its most cherished honors including the Presidency of the Society (1935–1936), and elected him an Honorary Member in 1947. He had served for several years on the Administrative Committee on Standards and was chairman of this important group. In Committee D-11 on Rubber and Rubber-Like Materials he made many contributions, notably as chairman of its important Subcommittee on Protective Equipment for Electrical Workers. He had been elevated to honorary membership in Committee D-11 in 1948. Perhaps his most significant contribution to the Society was as Chairman of the important Study Committee which in the late 1930's spent a great deal of time (including three 2-day sessions) evaluating all aspects of the Society's work, in particular its administrative setup. From this group came important recommendations to improve our operations.

Mr. Vassar was active in civic affairs and in church work, and the size of the gathering at his funeral was an indication of the respect accorded him.

His ASTM Presidential Address in 1936 on "The Testing of Non-Materials" was a thought-provoking message dealing with the question: "How far do we apply ASTM principles in our attitude toward certain social problems?" He stressed the fact that within the organized workers in the field of physical science "there is a potential force fully capable of being the leaven in the meal of society, which can aid mightily in the development of a more rational approach to the problems of the day." Noting that the challenge to Americans in 1936 was less spectacular than on Independence Day in 1776, and not a call to physical combat, he concluded: "But it does demand honest, intelligent, and unselfish thinking as each one does his part in bringing adequate standards to the testing of non-materials."

Probably no member of the Society has contributed more to ASTM than did Mr. Vassar. In closing this brief and inadequate tribute, we again pay homage to him, acknowledge his many contributions, and extend our sympathy to his family.

To the ASTM Committee on Membership

1916 Race St., Philadelphia 3, Pa.

Gentlemen:

Please send me information on membership in ASTM and include a membership application blank.

Signed ____________________

Address____________________

Date________________ ____________________

The Society Appoints . . .

Announcement is made of the following appointments of Society representatives

JEROME STRAUSS, Vanadium Corp. of America, as ASTM representative at the inauguration on October 12 of the new Stevens Institute of Technology President, Dr. Jess Harrison Davis, on the lawn of Castle Stevens on the campus at Hoboken, N. J. Mr. Strauss, widely known in the Society, is a Stevens' alumnus.

J. R. TOWNSEND, Bell Telephone Laboratories, Inc., reappointed as ASTM representative on the ASA Standards Council for a three-year term.

E. K. SPRING, Henry Disston and Sons, Inc., and G. O. HIERS, National Lead Co., on the Administrative Committee on District Activities, for terms of one and two years, respectively.

E. F. SEAMAN, U. S. Department of the Navy, Bureau of Ships, on the Administrative Committee on Simulated Service Testing for a term of one year.

E. R. STIVERS, Package Research Lab.; H. A. BERGSTROM, Continental Can Co.; A. V. GRUNDY, Chicago Quartermaster Depot; and T. A. CARLSON, U. S. Forest Products Lab., as ASTM representatives on the Joint ASTM-TAPPI Committee on Shipping Containers.

FRED BURGGRAF, National Research Council, as ASTM representative on the American Documentation Institute, succeeding R. W. CRUM, deceased.

W. S. HOUSEL, University of Michigan, as alternate on the Highway Research Board of the National Research Council, succeeding F. E. RICHART, deceased.

N. T. F. STADTFELD, Board of Water Supply, New York City, as an additional ASTM representative on ASA Sectional Committee A-21 on Cast Iron Pipe.

E. V. BENNETT, Bethlehem Steel Co., as ASTM representative on ASA Sectional Committee B-17 on Standardization of Shafting and Stock Keys.

W. J. KIERNAN, Bell Telephone Laboratories, Inc., as ASTM representative on ASA Sectional Committee Z-58 on Optics, succeeding M. REA PAUL.

Calendar of Other Society Events

"Long" and "short" calendars will appear in alternate BULLETINS. The "short" calendar notes meetings in the few immediate weeks ahead—the "long" calendar for months ahead.

AMERICAN OIL CHEMISTS' SOCIETY—October 8–10, 25th Annual Fall Meeting, Edgewater Beach Hotel, Chicago, Ill.

THIRTY-NINTH NATIONAL SAFETY CONGRESS AND EXPOSITION—October 8–12, Chicago, Ill.

THE ELECTROCHEMICAL SOCIETY, INC.—October 9–12, Annual Meeting, Hotel Statler, Detroit, Mich.

WORLD METALLURGICAL CONGRESS—October 15–19, American Society for Metals A.I.M.E., American Welding Society, Detroit, Mich.

AMERICAN ASSOCIATION OF TEXTILE CHEMISTS AND COLORISTS—October 17–19, Annual Convention, Statler Hotel, New York, N. Y.

NATIONAL INSTITUTE OF GOVERNMENTAL PURCHASING, INC.—October 21–24, Hotel Shoreham, Washington, D. C.

PACKAGING INSTITUTE—October 22–24, 13th Annual Forum, Hotel Commodore, New York, N. Y.

THE ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA—October 22, 23, 24, Twelfth Annual Water Conference, Hotel William Penn, Pittsburgh, Pa.

AMERICAN STANDARDS ASSOCIATION—October 22–24, National Standardization Conference, Waldorf-Astoria, New York, N. Y.

AMERICAN SOCIETY OF CIVIL ENGINEERS—October 22–25, Annual Convention, New York, N. Y.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS—October 22–26, Fall General Meeting, Hotel Cleveland, Cleveland, Ohio.

AMERICAN INSTITUTE OF PHYSICS—October 22–27, 20th Anniversary Meeting, Hotel Sherman, Chicago, Ill.

NATIONAL PAINT SALESMEN'S ASSOCIATION—October 25–27, Fourteenth Annual Convention, Hotel Traymore, Atlantic City, N. J.

NATIONAL PAINT, VARNISH AND LACQUER ASSOCIATION—October 29–31, Annual Convention, Chalfonte-Haddon Hall, Atlantic City, N. J.

AMERICAN CONCRETE INSTITUTE—October 30–31, Regional Meeting, Sheraton Hotel, St. Louis, Mo.

FOUNDRY EQUIPMENT MANUFACTURERS—October 31–November 2, Annual Meeting, The Homestead, Hot Springs, Va.

FEDERATION OF PAINT AND VARNISH PRODUCTION CLUBS—November 1–3, Annual Convention, Chalfonte-Haddon Hall, Atlantic City, N. J.

AMERICAN PETROLEUM INSTITUTE—November 5–8, 31st Annual Meeting, Stevens Hotel and Palmer House, Chicago, Ill.

TEXTILE RESEARCH INSTITUTE—November 8–9, Annual Meeting, New York, N. Y.

ELECTRON MICROSCOPE SOCIETY OF AMERICA—November 8–10, Annual Meeting, Franklin Institute, Philadelphia, Pa.

NATIONAL FOUNDRY ASSOCIATION—November 15–16, Annual Meeting, Waldorf-Astoria Hotel, New York, N. Y.

New Film on Instrumentation

UNDER the title "Information at Work," the Taylor Instrument Companies of Rochester, N. Y., has released a narrated 30-min, 16 mm, colored moving picture depicting the growth and significance of instrumentation. It is said to be the first film that portrays the phenomenal growth and importance of instrumentation in the great process industries of America. The film aims for a nice balance between education and entertainment. It contains sequences demonstrating control effects, instrument manufacture and instrument application, as well as scenes relating well-known end products such as food, film, plastics, petroleum and chemicals to controlled processing techniques. Also presented is a portrayal of the intricate steps in the manufacture of a mercury-in-glass thermometer.

The Taylor company is handling the distribution of the film, and requests for loan by technical societies, instrument engineers, science classes, civic clubs, etc., should be made to: Taylor Instrument Companies, Public Relations Dept., 95 Ames Street, Rochester 1, N. Y.

To the ASTM Committee on Membership, 1916 Race St., Philadelphia 3, Pa.

Gentlemen:

Please send information on membership to the company or individual indicated below:

____

____

This company (or individual) is interested in the following subjects: (indicate field of activity, that is, petroleum, steel, non-ferrous, etc.,)

____

Signed ____________________

Date________________ Address____________________

NEWS NOTES ON

Laboratory Supplies and Testing Equipment

Note—This information is based on literature and statements from apparatus manufacturers and laboratory supply houses.

Catalogs and Literature

Pressure Transmitters—Engineering Data Folders illustrate and describe the complete line of pressure measurement transmitters including the Bourdon Tube Pressure Transmitter, with range of 15–10,000 psi; gage Pressure Bellows Transmitter with range of 0–10 in. of water to 0–200 in. of water; Absolute Pressure Transmitter with range of 0–50 mm of mercury to 0–30 in. of mercury; Differential Pressure Cell with range of 0–20 in. of water to 0–300 in. of water.

Automatic Temperature Control Co., Inc., 5200 Pulaski Ave., Philadelphia 44, Pa.

Low Resistance Tester—Four-page Bulletin 3051 illustrates and describes portable Model 151-S Microhm Meter for measuring down to one microhm. (0.000001 ohm). The instrument permits checking of circuit breaker contacts without disassembling the breaker and is also used in detecting abnormally high resistances in cable joints, bus bar connections, windings, etc.

J. W. Dice Co., Englewood, N. J.

Draft Gages and Portable Gas Analyzers—The Ellison Draft Gage Co. has just released its new Bulletins 109 and 120. Bulletin 109 (20 pages) offers engineers and laboratory technicians concerned with combustion, ventilation, and heating, a complete description of Ellison portable, stationary, and laboratory types of inclined draft gages and accessories. It includes instructions for securing readings in conjunction with Ellison pilot tubes, suggestions for use of draft gages in studying domestic heating plants, as well as velocity tables and other useful data. Bulletin 120 (4 pages) offers a review of specifications, features, and applications of the Ellison Portable Gas Analyzer for measuring CO_2, O_2, and CO. Unit-by-unit discussion presents details of construction and advantages of component parts together with a complete explanation of equipment.

Ellison Draft Gage Co., Inc., 214 W. Kinzie St., Chicago 10, Ill.

Gas Analysis—A new edition of a reference manual describing the theory and practical application of gas analysis has been issued by the Fisher Scientific Co. It is the fourth revised edition, rewritten to bring together all the up-to-date information on the subject, as well as the latest Fisher equipment for gas analysis. The 60-page manual discusses the theory of gas analysis and goes into considerable detail regarding the procedures involved in the various analyses. Complete instructions on maintaining and operating the equipment are given, and the extensive assortment of Fisher "Unitized" gas analysis apparatus is illustrated and described in detail.

Fisher Scientific Co., 717 Forbes St., Pittsburgh 19, Pa.

Recording Air Pollution by SO_2—A new brochure published by Leeds & Northrup describes the use of that firm's Thomas Autometer for measurement of very small traces of SO_2. According to the brochure, these small traces are of great significance to air pollution surveys but they cannot be measured with satisfactory reliability by conventional gas analysis methods. The equipment described is entirely automatic and records on a wide stripchart, concentration directly in parts of SO_2 per million parts of air. Unlike most gas analyzing equipment, the Thomas Autometer employs electrolytic conductivity as the means of measurement. A continuous sample of air is pumped countercurrent to the flow of a hydrogen peroxide-sulfuric acid solution in an absorbing column, where the SO_2 is absorbed and oxidized to the sulfate ion. The resulting change to electrolytic conductivity of the solution is detected by a conductivity cell and is recorded directly in parts of SO_2 per million parts of air on a continuous chart by means of a Speedomax Recorder. The brochure is fully illustrated with cuts and diagrams. 8 pages.

Leeds & Northrup Co., 4907 Stenton Ave., Philadelphia 44, Pa.

Instrument Notes

Vest Pocket 9 Channel Oscillograph—Up to nine sources of data representing vibration, pressure, velocity, strain, or other phenomena, either static or dynamic, can record simultaneously on the new 5 by 5 by 8-in. recording oscillograph, Type 5-118, just released by Consolidated Engineering Corp. of Pasadena, Calif. Operating from a 28-volt d-c power source, this highly compact test instrument is suited to mobile testing programs, where space and weight saving are of importance and yet highly accurate results are required. Developed originally for a missile testing program, this new midget oscillograph produces dynamic test records $3\frac{1}{2}$ in. wide and up to 40 ft long on which the nine separate phenomena can be measured with respect to both time and one another. The Type 5-118 recording oscillograph employs the same standard Type 7-200 galvanometers as used in the firm's larger oscillographs (Types 5-114 and 5-116). The galvanometers are mounted in a stable, cast magnet block and are easily reached for adjustment or replacement when the film magazine is removed. Sensitivity of these galvanometers is said to be such that frequently no amplification is needed.

Consolidated Engineering Corp., 300 N. Sierra Madre Villa, Pasadena 8, Calif.

SPI Flammability Tester—The SPI flammability tester developed by the Society of the Plastics Industry to measure the flammability hazard of various sheet materials is now available from Custom Scientific Instruments, Inc. The instrument can accept materials from 0.001 to 0.250 in. thick or more, including plastics, textile fabrics, rubber, paper, etc., varying from very flammable to extremely flame resistant. Descriptive literature is available from the manufacturer.

Custom Scientific Instruments, Inc P. O. Box 170, Arlington, N. J.

Sheet Metal Tester—J. Arthur Deakin & Son, national representatives for George H. Alexander Machinery, Ltd., announce the introductiion of the Alexander Sheet Metal Tester for making the Erichsen Test. The test determines the "workability" of ferrous, non-ferrous, and fine metal sheets and strips to the point of fracture. This tester will handle material up to $\frac{5}{64}$ in. thick. In performing the test a test piece is clamped between two dies and is held so that the metal has "play" and can flow, while a perfect round-end tool is moved forward gradually by the handwheel until fracture occurs. The operator constantly observes the image of the test piece in a mirror, and when fracture appears, the depth of the impression is read directly from a micrometer scale. Readings are said to be obtained to 0.0004 in. Test pieces of $3\frac{1}{2}$ in. square and sheets or strips up to $2\frac{7}{16}$ in. wide can be tested with standard tools. Additional interchangeable tools can be supplied for checking narrow strips up to $\frac{25}{64}$, $\frac{3}{4}$, and 1 in. wide, for coin blanks and to determine the "deep drawing value" of materials. Another feature is a direct reading pressure gage that registers the pressure exerted on the fracture point of the material.

J. Arthur Deakin & Son, 130-28 Hillside Ave., Jamaica 2, N. Y.

High Speed Camera Modification—A modification of the Kodak High Speed Camera which permits both the mechanical and electrical aspects of a subject to be recorded simultaneously on the same film has been announced by the Eastman Kodak Co. The modification consists of the addition of a second lens to the camera to record the images on the tube of a cathode ray oscillograph through the back of the film, while the mechanical aspects of the subject are being photographed on the front. This record will permit the photographer to present a complete picture of the behavior of electromechanical devices, and will also permit easy correlation with strain, acceleration, vibration, and other signals fed to the oscillograph in many nonelectrical problems. The oscillographic

modification can be added to Kodak High Speed Cameras or Eastman High Speed Cameras Type III, previously purchased.
Eastman Kodak Co., Rochester 4, N. Y.

Carbon Determinator—A new carbon determinator said to permit rapid and precise analysis for iron and steel of very low carbon content has been announced. Using the new carbon determinator called the "LECO CD-10 Conductometric Carbon Determinator," analysis time for most types of iron and steel is said to be only five to ten minutes with the results obtained comparing favorably with those by low pressure methods. In this method, a sample is combusted in oxygen in a conventional resistance or high frequency induction type furnace, and the amount of carbon dioxide resulting is established by measuring the change in conductivity (reciprocal ohms) of a barium hydroxide solution through which the carbon dioxide is passed. Literature is available on request.
Laboratory Equipment Corp., St. Joseph, Mich.

Induction Furnace—A newly announced high frequency induction furnace is available to the chemist for burning iron and steel samples for combustion carbon analyses. The furnace, designated "IH-10," features: instantaneous starting of combustion and complete burning of the sample; small current consumption; long combustion tube life; lack of heat-up period; speedy performing of test; cooler operating conditions; convenient sample loading; and temperatures in excess of 3000 F permitting successful burning of tungsten carbide and jet alloy samples. Descriptive literature on the instrument is available.
Laboratory Equipment Corp., St. Joseph, Mich.

Fluorescent Illuminator for Analytical Balances—Known as the "Royalton Balance Illuminator," a new product embodies a novel principle of operation which is said to eliminate the magnetic interference, vibration, and cyclical hum stated as common faults of other balance lights. In the new illuminator the ballast is located on the wire near the plug, six feet away from the balance, where heat or other emission from it cannot interfere with the proper operation of the balance. The illuminator is fitted with soft rubber feet and sets on top of the balance. It does not require screws, clamps, or other fittings to fit any conventional type analytical balance.
Meyer Scientific Supply Co., Inc., 215 N. Eighth St., Brooklyn 11, N. Y.

Oxygen Combustion Bombs—New oxygen combustion bombs for microanalyses, for testing explosives, and for high precision calorimetry are described in an eight-page bulletin just published. Accessories for oxygen bomb tests are also described, and recent improvements and revisions in oxygen bomb ASTM test methods are summarized. These new bombs extend the usefulness of oxygen combustion methods to the testing of explosive materials, and to microprocedures for which the commonly used Parr single-valve and double-valve self-sealing calorimeter bombs are not well suited.
Parr Instrument Co., 212 Fifty-Third Street Moline, Ill.

Unbonded Resistance Wire Strain Gage—A new unbonded resistance wire strain gage for the measurement of tensile and compressive strains is said to be useful for strain measurement in structural testing, experimental stress analysis, and strength of materials research. The strain gage is furnished with knife edges for specimen engagement, and exhibits electrical characteristics similar to those of the cemented type. The over-all dimensions are approximately $2\frac{1}{4}$ in. long by $\frac{3}{4}$ in. wide by $\frac{3}{4}$ in. high. Two active bridge arms are incorporated, and the instrument may be operated with strain indicators of all types currently used with bonded strain gages. The principal advantages of this unbonded strain gage are that it may be used immediately upon attachment to the specimen and that it may be used repeatedly without destruction of the strain gage.
Statham Laboratories., Inc., 12401 W. Olympic Blvd., Los Angeles, Calif.

Alpha Beta Gamma Survey Meter—A new Alpha Beta Gamma Survey Meter with an optional probe for alpha detection and many new design features, is announced. Developed for use as both a radiation dosage rate meter and for Civil Defense use as a low-level contamination monitor, the instrument, called the SU-5A, has proved helpful in the laboratory for checking small amounts of spilled radiochemicals according to the manufacturer. In addition, the instrument can be used to locate radium, for monitoring the amount of radiation from Oak Ridge isotope shipments and the measuring of dosage rates from stored radioisotopes, to ascertain whether adequate shielding has been employed. The new instrument is waterproof, lightweight, battery operated, and is provided with two sets of scale ranges, enabling reading to be made in both mr/hr and cpm.
Tracerlab, Inc., 130 High St., Boston 10, Mass.

Hydraulic Laboratory Press—A new 12-ton hydraulic Laboratory Press featuring flexibility of operation has been announced. A gage, mounted in the control panel, indicates pounds per square inch on the ram. The stroke is 6 in. and the maximum daylight opening is 10 in. Longer columns can be supplied at a slight additional charge to provide more opening if required. Stated as an unusual feature of this model is the paralleling of the platens which has been accomplished by precision boring of the guide holes. The platen area is 70 sq in. (7 by 10 in.); width between columns is 11 in. Height is 36 in. A bimetallic type of temperature regulator and relayed load method is used. Temperature range is from 0 to 600 F.
Wabash Metal Products Co., P. O. Box 305, Wabash, Ind.

INSTRUMENT COMPANY NEWS . . . .

Announcements, changes in personnel, new plants and locations, and other notes of interest

Bausch & Lomb Optical Co., Rochester, N. Y. Promotion of Herbert J. Mossien as head of the Analytical Instrument Sales Department at Bausch & Lomb Optical Co. has been announced. The youngest department head in the firm's Scientific Instrument Division, he succeeds Kenneth E. Reynolds, who recently was appointed head of Bausch & Lomb's newly created Defense Contract Department.

Branson Instruments, Inc. have moved their facilities to a new plant at 430 Fairfield Ave., Stamford, Conn. The new building has twice the floor space of the previous location, and will enable the Company to expand its production of ultrasonic thickness gages, ultrasonic flaw detectors, and other electromechanical devices.

Fish-Schurman Corp., 70 Portman Rd., New Rochelle, N. Y. As of July 23 this firm has been occupying its new enlarged plant in New Rochelle, N. Y. The building has considerably enlarged facilities for optical instrument making, optical surfacing, and vacuum coating. The "Steelset" Diamond Department is also enlarged. The plant may be conveniently reached from New York by car or train.

Fisher Scientific Co., 7722 Woodbury Dr., Silver Spring, Md. A 16-page booklet describing the new Washington Plant of the Fisher Scientific Co. in Silver Spring, Md., is available on request. It is illustrated with views of the new plant as well as the Company's manufacturing units in Pittsburgh, Edgewater, N. J., and New York City. The Washington Plant was built by Fisher Scientific Co. in 1950 and was opened for business at about the beginning of 1951. The booklet, now being offered for the first time, emphasizes the facilities built into the new plant for fast, convenient handling of orders for the Company's customers in the Washington area and throughout the Southeast.

Jarrell-Ash Co., 165 Newbury St., Boston 16, Mass. Announcement is made of the appointment of John A. Schuch as the Jarrell-Ash Co.'s Midwest Representative. His address will be Detroit, Mich. Mr. Schuch was formerly Chief Engineer of Harry W. Dietert Co., Detroit, Mich.

Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia 44, Pa. Appointment of Dr. Raymond C. Machler, Germantown, as Director of Research and a member of the Executive Committee of Leeds & Northrup Co., manufacturers of electrical measuring instruments, automatic controls, and heat-treating furnaces, has been announced. Dr. Machler, formerly Associate Director of Research, succeeds I. Melville Stein, who recently was elected to the newly created post of Executive Vice-President. At the same time it was announced that J. C. Peters, Associate Director of Research, will be joined in that capacity by G. A. Perley and A. J. Williams, Jr. Both formerly were Assistants to the Director in the Company's Research Department.

Impact Properties of Stainless Steel and 9 Per Cent Nickel Steel After Exposure Under Stress to Liquid Nitrogen

By T. N. Armstrong[1] and A. J. Miller[2]

THE effect of variables such as composition, deoxidation practice, microstructure, and cold working on the notched bar impact properties of ferrous materials are rather generally known as they have been the subject of much study over the past several years. It also has been determined on a limited number of steels that long exposure times at low temperature appear to have little influence on properties. Specimens of chromium-nickel stainless steels, 9 per cent nickel steel, and 3½ per cent nickel steel immersed in liquid nitrogen for a period of one year had substantially the same impact properties after exposure, both at room temperature and at low temperatures, as specimens that had not been subjected to continuous cold treatment.[3]

There has been some inference that austenitic chromium-nickel stainless steels suffer deterioration in impact properties when exposed to low temperatures for a long period while under stress. In order to determine the effect of applied stress on several steels exposed to low temperatures for long periods, a test was conducted of types 310 and 316 stainless steels and 9 per cent nickel steel, AISI 2800.

The chemical compositions in per cent of the three materials were as follows:

AISI Type	C	Mn	Si	Ni	Cr	Mo
2800 (9 per cent Ni).....	0.10	0.77	0.28	8.56	...	..
310 (25-20).............	0.11	1.51	0.42	21.64	27.22	..
316 (18-8-Mo)..........	0.08	1.54	0.56	12.01	17.65	2.74

Specimens were prepared from pieces of the two stainless steels in the annealed condition and from pieces that had been butt-welded by the metal-arc process using covered electrodes of the same type as the base plate. The welded specimens were tested in the as-welded condition.

The 9 per cent nickel steel was double normalized and reheated to 1050 F. The butt welds in this steel were made with type 310 electrodes and the welded specimen reheated to 1050 F and cooled in air subsequent to welding.

Each specimen was threaded on both ends with sufficient length between the threads to prepare two impact specimens. A jig of the same material as the material being tested was constructed and a stress of 30,000 psi in tension applied to each specimen by adjusting the nuts on the ends of the specimens. The actual stress was determined by strain gage readings. The assembly, with strain gages attached, is shown in Fig. 1.

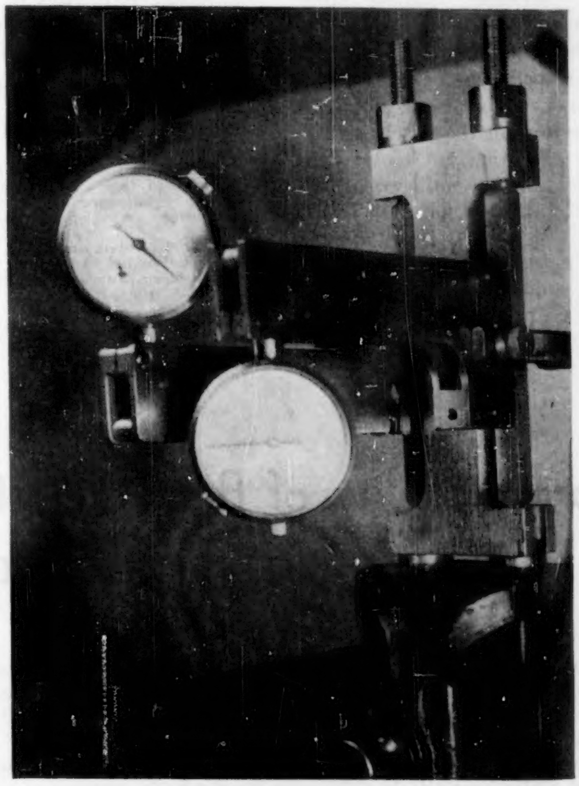


Fig. 1.—Specimens in Jig. Desired Stress Obtained by Adjusting Nuts Until Correct Deflection Shows on Gages.

The jigs, each containing two specimens under stress of 30,000 psi, were immersed in liquid nitrogen. After exposure, the stressed specimens were removed from the jig, notched, and

TABLE I.—CHARPY IMPACT (FT-LB) OF STAINLESS STEELS AT −320 F, KEYHOLE NOTCH.

Type Stainless Steel	Plate		Weld	
	Unstressed	Stressed 30,000 psi 13 days	Unstressed	Stressed 30,000 psi 13 days
310......	49, 50, 48	50, 50, 45	22, 26, 27	26, 27, 28, 32
316......	64, 65, 26	58, 62	18, 16, 18	22, 21, 24

TABLE II.—CHARPY IMPACT (FT-LB) OF 9 PER CENT NICKEL STEEL AT −320 F, KEYHOLE NOTCH.

	Unstressed	Stressed 30,000 psi		
		2 days	2 weeks	2 months
Plate............	25, 26, 30	24, 28, 29, 37	18, 20, 23, 28	24, 28, 29
Weld interface....	20, 26, 26	20, 24, 25, 26	17, 21, 24, 25	23, 26, 26, 26

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] Development and Research Division, The International Nickel Co., New York, N. Y.

[2] Research Laboratory, The International Nickel Co., Bayonne, N. J.

[3] T. N. Armstrong and A. J. Miller, "Notched Bar Impact Properties of Some Nickel Steels After One Year Exposure to Liquid Nitrogen," National Conference on Petroleum, *Mechanical Engineering*, Am. Soc Mechanical Engrs. (1946).

cooled to −320 F before testing. The stressed specimens of stainless steel were tested after two weeks exposure, and the 9 per cent nickel steel stressed specimens were tested after exposure periods of 2 days, 2 weeks, and 2 months.

The stainless steels were notched in the unaffected base metal and in the weld metal. Welded stainless steel specimens were not stress relieved. Results are shown in Table I.

The impact specimens of the welded 9 per cent nickel steel were prepared so that the bottom of the notch was at the interface of the parent metal and the weld metal. Results of tests of the 9 per cent nickel steel are shown in Table II.

It will be noted that the results of test of each condition of a particular material fall within a scatter band that does not appear to be affected by the length of exposure under stress at low temperature. The one low value for type 316 was from an unstressed specimen and is believed to reflect an abnormality.

Tests at room temperature, except for check purposes, were not conducted, as impact properties of the three materials at ambient and low temperatures are adequately covered in the literature.[4,5]

The results indicated that stress up to 30,000 psi had not affected the impact properties of the two stainless steels when exposed under an applied stress of 30,000 psi for two weeks to liquid nitrogen.

The tests on the stainless steels were not continued for a longer period as it is believed that if no change occurs in a few days at low temperature, it is unlikely that change will take place if the exposure time is continued indefinitely.

Impact properties of 9 per cent nickel steel under an applied stress of 30,000 psi were not affected when exposed to liquid nitrogen for a period of two months. Similar specimens of 9 per cent nickel steel under test at L'Air Liquide Society, Montreal, P. Q., have shown no deterioration after a period of six months and the test is being continued until a year has elapsed.

[4] T. N. Armstrong and G. R. Brophy, "Some Properties of Low Carbon 8½% Nickel Steel," National Conference on Petroleum, *Mechanical Engineering*, Am. Soc. Mechanical Engrs. (1947).

[5] V. N. Krivobok and R. D. Thomas, "Impact Tests of Welded Austenitic Stainless Steels," *The Welding Journal*, Research Supplement, September, 1950, p. 493.

Reproducibility of Bend Test for High Hardness Steels

By L. D. Jaffe[1] and D. C. Buffum[1]

SYNOPSIS

High-carbon alloy steel specimens were given a single heat treatment that produced a Rockwell hardness of C 52½. The strength of these specimens was determined by bending under two-point loading until rupture occurred.

The results thus obtained, together with those in the literature, were analyzed mathematically to determine the minimum number of specimens necessary to determine, with a high degree of certainty, which of two materials has the higher bend strength.

In the study of mechanical properties of steel at high hardness it is necessary to have a sensitive and reproducible measure of the ability of a specimen to deform before breaking. It was thought that the strength in bending,[2] if sufficiently reproducible, could be used as the measure.

A report by Grobe and Roberts[3] indicated that it would be necessary to use approximately 20 specimens to obtain the degree of precision desired. However, on examination of the data presented in their report, it appeared that for research experiments fewer specimens might be used if the number of variables in preparing, heat treating, and testing the specimens was kept to a minimum. The object of this investigation was to determine the smallest number of bars that can be used to obtain the necessary precision. In the course of the work it was found necessary to examine further the degree of precision needed.

Procedure

The material used in this experiment was a commercially produced steel of the following chemical composition (in per cent):

Carbon	0.66	Nickel	0.19
Manganese	0.84	Chromium	0.14
Silicon	0.27	Molybdenum	0.89
Sulfur	0.019	Aluminum	0.015
Phosphorus	0.023		

Twenty specimen blanks were heat treated in 5-in. lengths ½ in. in diameter. The blanks were austenitized at 1900 F (1035 C) for 1 hr, quenched in water for 2 sec and then quenched in oil to room temperature. This treatment produced a structure that was essentially 100 per cent martensite (some retained austenite may have been present) with all carbides in solution and an ASTM austenitic grain size of 5–6. The quenching was followed by a temper at 400 F (205 C) for 1 hr, from which the specimens were water-quenched. The average Rockwell hardness of the specimens was C 52½.

After heat treating, the bars were inspected for flaws and 8 of the 20 bars were found to have quench cracks. The 12 sound bars were centerless ground down to 0.4 in. diameter. The specimens were broken using two-point loading (Fig. 1).

Results and Conclusions

In Table I the bend strengths of the specimens are tabulated along with a statistical survey of the data. The survey shows the standard deviation of a single measurement to be 25,500 psi or 4.8 per cent of the mean as compared

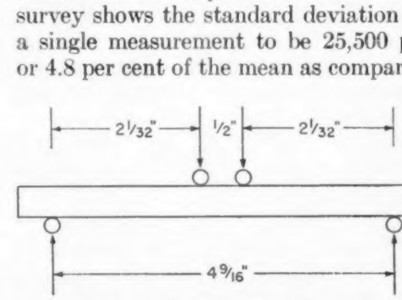


Fig. 1.—Arrangement of Two-Point Loadings.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] Watertown Arsenal, Watertown, Mass.

[2] The bend strength in this paper is defined as the maximum fiber stress as calculated from the maximum load on the basis that the specimen acted as a simple elastic beam.

[3] A. H. Grobe and G. A. Roberts, "The Bend Test for Hardened High Speed Steel," *Transactions*, Am. Soc. Metals, Vol. 40, pp. 435–470 (1948).

TABLE I.—BEND STRENGTHS AND STATISTICAL SURVEY

Specimen	Bend Strength, psi
No. 21.....	543 000
No. 22.....	510 000
No. 23.....	491 000
No. 24.....	531 000
No. 25.....	504 000
No. 26.....	507 000
No. 27.....	523 000
No. 28.....	533 000
No. 29.....	549 000
No. 30.....	576 000
No 31.....	567 000
No. 32.....	530 000

Average bend strength = $\overline{X}$ = 530,361 psi.
Summation of (bend strength)^2 = ΣX^2 = 3382×10^9 (psi)^2.
Number of specimens = n = 12.
Standard deviation of a single measurement = $\sigma = \sqrt{(\Sigma X^2/n) - \overline{X}^2}$ = 25,500 psi = 4.8 per cent.

with 5.1 per cent of the mean in the work of Grobe and Roberts.

Other work[4] has been done on a single heat treatment of alloy steel containing 0.65 per cent carbon. Sixteen specimens were used with a square cross-section of 0.394 in. on a side. The method of testing was the same as used in this investigation. On these specimens the standard deviation of a single measurement was 6.2 per cent of the mean.

It is recognized that the twelve specimens tested in the present study are not enough to establish the scatter obtained in bend strength determinations. In view of the agreement between the results of the three investigations, however, it appears that the standard deviation of a measurement may be taken as about 5 per cent of the mean.

It was desired to know how many specimens are necessary, with this scatter, to determine whether one heat treatment or composition, B, gives a higher bend strength than another, A. The number of specimens will evidently depend upon the separation between the true mean strengths of the two materials and upon the desired degree of assurance that the conclusion drawn is correct. Let the true means for the two materials be a and b, with b being greater, and assume that the distributions are Gaussian and have the same standard deviation σ.

Suppose n specimens of A and n specimens of B are measured. What is the likelihood of the mean of the n specimens of A being higher than the mean of the n specimens of B, so that it would be incorrectly concluded from this test that A is stronger than B? The statistics of this problem have been considered by Eisenhart,[5] who tabulates this likelihood for values of n from 2 to 200 and various values of $(b - a)/\sigma$. By cross-plotting Eisenhart's results, the points in Fig. 2 were obtained.[6] This figure shows the number of specimens necessary to assure 95 and 99 per cent certainty of drawing the correct conclusion for various values of the difference between the true means, a and b. This difference is given in terms of $(b - a)/\sigma$ at the bottom of graph and in terms of percentage, for $\sigma = 5$ per cent of the mean, at the top.

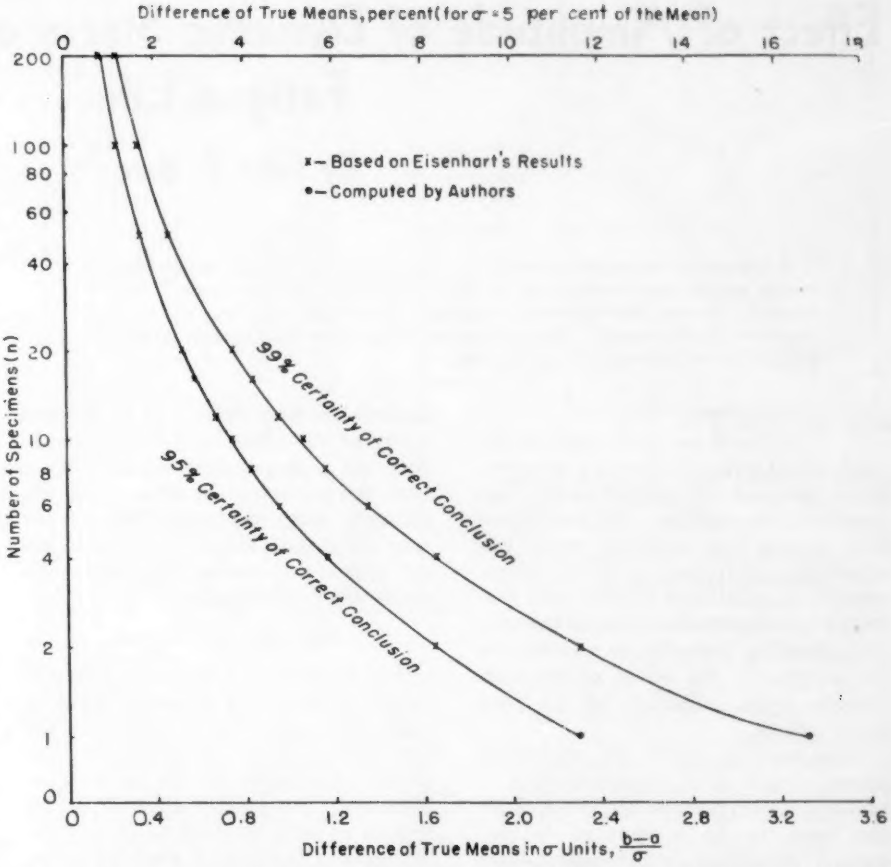


Fig. 2.—Number of Specimens Required to Assure the Difference of Specimen Means Is in Same Direction as Difference of True Means.

A difference in bend strength between two lots of high hardness steel, differing in heat treatment or composition, would have to amount to at least 5 per cent to be of interest to metallurgists or engineers. If two lots differ by 5 per cent in bend strength, Fig. 2 shows that a test of six specimens from each would correctly indicate the stronger 95 per cent of the time. Six specimens would correctly indicate a 7 per cent difference in bend strength over 99 per cent of the time.

Sometimes a difference between two lots would not be of interest unless it amounted to at least 10 per cent. For two lots differing by 10 per cent in bend strength, duplicate tests would correctly indicate the stronger over 95 per cent of the time (Fig. 2). Triplicate tests would show it correctly over 99 times out of a hundred.

It should be mentioned that the results of this investigation cannot be directly applied to specifications. The statistical analysis necessary for such an application would be different from that outlined above. Also, the method of obtaining specimens representative of production parts is an entirely separate and difficult problem, which is not considered herein and would be of great importance in a specification.

Conclusion

1. It is concluded that, for two materials whose bend strengths differ by 5 per cent or more, bend tests run in sextuplicate will show which is stronger with a high degree of certainty. If differences less than 10 per cent are not of interest, tests in duplicate or triplicate will be sufficient.

2. This result applies only to research investigations and not to the use of bend test in specifications.

Acknowledgment:

The authors wish to thank Messrs. O. Bowie and F. Devine of Watertown Arsenal for their assistance in the computations, and Mr. J. F. Sullivan for his suggestions on the statistics.

[4] E. Hutchinson, unpublished data, Watertown Arsenal.

[5] C. Eisenhart, M. W. Hastay, and W. A. Wallis, "Techniques of Statistical Analysis," McGraw-Hill Book Co. New York, N. Y., pp. 377–382 (1947).

[6] The points for $n = 1$ were computed and other points checked by the authors, with the assistance of F. Devine and O. Bowie, using a method basically the same as Eisenhart's.

Effect of Amplitude of Dynamic Stress on High Temperature Fatigue Life

By John E. Breen[1]

SYNOPSIS

A dynamic stress superimposed on a test specimen during a stress-rupture test generally causes a decrease in the rupture life of the specimen. At low dynamic stresses, the decrease in rupture life is slight, and in some cases it may even be increased. But, in general, the greater the dynamic stress the greater is the decrease in rupture life.

The great bulk of the work on materials at elevated temperatures has centered around stress rupture and creep testing. High-temperature fatigue has received much less attention. However, many high-temperature applications require that materials be subjected to repeated stresses. It is therefore desirable to establish as far as possible the effect of dynamic stresses upon materials at elevated temperatures.

Manjoine,[2] in work on aluminum alloys, found that superimposing a cyclic stress on a creep test may cause the creep to be accelerated or decreased, depending on the combination of static and dynamic stresses. Lazan[3] also showed on heat-resistant alloys that large cyclic stresses decrease the rupture life of the specimen. From his data it can be seen that low cyclic stresses have little effect on the rupture life and at high temperatures may increase the rupture life.

Simmons and Cross[4] showed similar results on the high-temperature alloys that they tested. Greenwood and Cole[5] using lead alloys, and the National Advisory Committee on Aeronautics,[6] using a heat-resistant alloy, have also investigated the effect of combined static and dynamic stresses.

The work reported in this paper was undertaken to provide a more detailed study of the effect of dynamic amplitude on a single-phase material at a high temperature. In these tests the dynamic stress was varied from 0.0 per cent of the static stress to as close to 100 per cent as practicable, while the static stress was held constant.

METHODS OF TESTING

Any method that is used for fatigue testing of metals at elevated temperatures must allow for the fact that the test specimen invariably is subjected to creep deformation at the same time. This creep can greatly affect a fatigue test by causing the load to be relaxed. Therefore it is desirable when using any fatigue-testing machine at high temperatures to provide some means for maintaining the load constant throughout the test.

For this work the Sonntag Direct Stress Fatigue-Testing Machine model SF-4 was used. This is a constant-load machine in which the preload (static stress) is applied by a pair of large flexible springs and in which the dynamic load is applied by an eccentric weight revolving at 3600 rpm. A calibration of the fatigue machine used in these tests showed that the indicated applied preload was approximately correct but that the indicated applied dynamic load was less than the actual load on the specimen. The calibration further showed a distortion in the expected sinusoidal form of the load wave, especially when the dynamic load exceeded 60 per cent of the static load. However, all tests for this present work were run on the same machine; thus the relative values for the dynamic stress will be correct even though the absolute values may be slightly in error.[7]

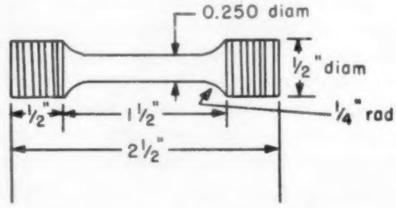


Fig. 1—Fatigue Specimen.

The material selected for this series of tests was alpha brass (70 per cent copper - 30 per cent zinc), a single-phase material that undergoes no transformations. All specimen material was annealed at 1000 F for 16 hr. A grain size determination was made on the material before testing and on several of the test pieces after fracture. In all cases there were approximately 350 grains per sq mm which is equivalent to ASTM grain size of 5 to 6. The $\frac{1}{4}$-in. diameter specimen used is shown in Fig. 1.

DISCUSSION AND RESULTS

Figures 2 and 3 show the effect of the amplitude of the dynamic stress upon the rupture life of alpha brass at 550 F at two different mean stresses. The figures show dynamic stress plotted against the logarithm of the "cycles to fracture." Since the fatigue machine is operated at a fixed rate (3600 rpm), the cycles to fracture is directly proportional to the time to rupture; therefore the dynamic stress is also plotted against the logarithm of the time to rupture. In Fig. 2 the static stress is 12,000 psi,

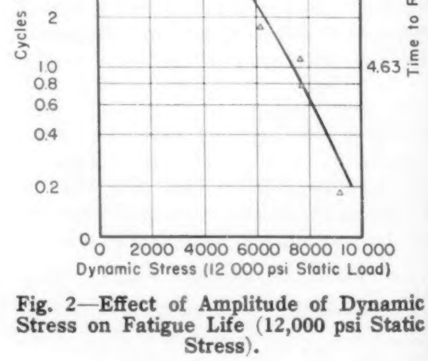


Fig. 2—Effect of Amplitude of Dynamic Stress on Fatigue Life (12,000 psi Static Stress).

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[1] Member of the High Temperature Alloys Branch, Metallurgy Division, Naval Research Laboratory, Washington, D. C.

[2] J. H. Manjoine, "Effect of Pulsating Loads on the Creep Characteristics of Aluminum Alloy 14S-T," *Proceedings*, Am. Soc. Testing Mats., Vol. 49, pp. 788–798 (1949).

[3] B. J. Lazan, "Dynamic Creep and Rupture Properties of Temperature Resistant Materials Under Tensile Fatigue Stresses," *Proceedings*, Am. Soc. Testing Mats., Vol. 49, pp. 767–787 (1949).

[4] Record of Conference on Fatigue of Metals at High Temperatures; Technical Report 21, Project Squid; Compiled by H. J. Yearian, Edited by P. K. Porter; Cornell Aeronautical Lab., Inc., May 24, 1950.

[5] N. J. Greenwood and J. H. Cole, "The Influence of Various Factors on the Creep of Lead Alloys," *Metallurgia*, Vol. 39, pp. 121–126 (1949).

[6] "Cooperative Investigation of Relationship between Static and Fatigue Properties of Heat Resistant Alloys at Elevated Temperatures," *N.A.C.A. Research Memorandum 51A-4*, N.A.C.A. Headquarters, Washington, March, 1951.

[7] The author, in consultation with the Sonntag Co., determined the sources of error in the machine so that appropriate methods could be used to compensate for them. By taking special care to align the specimen properly and by locking the specimen securely, the distortion in the strain wave can be eliminated.

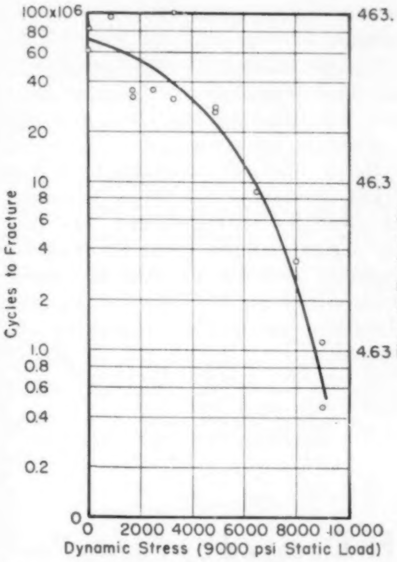


Fig. 3—Effect of Amplitude of Dynamic Stress on Fatigue Life (9000 psi Static Stress).

while in Fig. 3 it is 9000 psi. Figure 2 shows that even a small superimposed dynamic stress reduces the rupture life at a mean stress of 12,000 psi. As the amplitude of the dynamic stress is increased, the rupture life is progressively decreased. At a mean stress of 9000 psi the same general trend is shown, but in this case the values show more scatter. In Fig. 3, there are several values (at 878 and 3310 psi, respectively) that lie considerably higher than the best curve that can be drawn through the rest of the points. In fact these points lie higher than the stress-rupture value for this series of tests. The author has no explanation as to why these specimens appear so much stronger than the others. The scatter of points in Figs. 2 and 3 is probably no greater tnan one should expect in high-temperature fatigue testing. It is felt that in spite of the few points that lie high, the overwhelming evidence as demonstrated in Figs. 2 and 3 shows a decrease in rupture life with an increase in dynamic stress.

An indication of the ductility is given

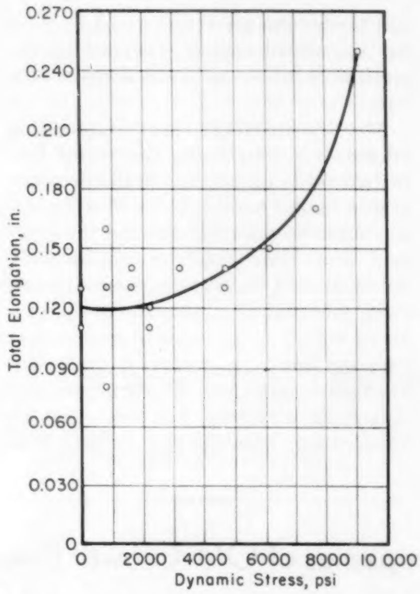


Fig. 4—Effect of Amplitude of Dynamic Stress on Ductility (12,000 psi Static Stress).

in Figs. 4 and 5 in which the total elongation at rupture is plotted against the dynamic stress. Here again, there is a wide scatter in the data, but a very definite trend can be seen. A small superimposed dynamic stress has no consistent effect on ductility. This is especially clear-cut in the case shown in Fig. 5. At high values of dynamic stress there is a large increase in ductility with increasing dynamic stress. At high stresses (either instantaneous or steady) there is an increase in the strain rate. This in turn causes the specimen to behave in a more ductile manner.

The fracture of the specimens at high dynamic stresses is a transcrystalline fracture with a very slight amount of necking. At lower dynamic stresses the fracture appears to be a typical fatigue-type fracture; that is, the fracture appears to have started as a crack on the surface and propagated transversely until the remaining cross-sectional area could not carry the load. This fracture is not unlike the intercrystalline frac-

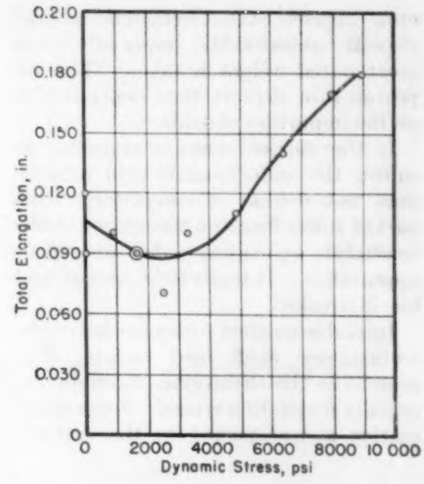


Fig. 5—Effect of 'Amplitude of Dynamic Stress on Ductility (9000 psi Static Stress).

ture obtained in a stress-rupture test of a medium grain size specimen.

Conclusions

1. Using a single-phase material (alpha brass), the general trend was for fatigue stresses to decrease specimen life in proportion to their magnitude. At low dynamic stress the effect was slight and there was considerable scatter in the data. Several low amplitude tests lasted for exceptionally long times.

2. Ductility (as measured by elongation) generally increased with an increase in the magnitude of the dynamic stress. However, at low values of dynamic stress there was no consistent effect.

Acknowledgment:

This program was initiated under the direction of D. J. Blickwede. The author wishes to thank J. R. Lane and O. T. Marzke for their encouragement and suggestions. He thanks the other members of the High-Temperature Alloys Branch, Metallurgy Division, for their help. The calibration of the fatigue testing machine by Robert F. Conrad, Mechanics Division, Naval Research Laboratory, is appreciated.

Discussion of Paper on Electro Analysis of Copper[1]

Jorma Kinnunen.[2]—It is surprising to read about the great use of electrolytic copper determination in brass mills since the volumetric iodide method is more rapid and simple and also sufficiently accurate in the daily control. One reason may be that the electrolytic method permits the simultaneous determination of lead in the case of leaded brass. At present the spectrophotometric method may also be used.

It is necessary in the daily control that the electrodes be rigid. Gauze with wire diameter 0.25 mm or 0.21 mm is preferred to 0.12 mm, which requires very cautious handling. Unfortunately the electrodes at present commercially available in Europe often leave in this respect much to be desired.

It is generally known that the anode decreases in weight during electrolysis. This effect, which is very pronounced in the determination of nickel, must also be taken into account in the determination of copper, if the greatest accuracy is required, and this effect cannot be avoided by using an anode of pure iridium or rhodium.[3] This loss is mainly transported to the cathode.

The effect of halogens and organic matter can be considered also from the viewpoint of "additional agents," as used in the electrolytic copper refineries, that is, quite small amounts of hydrochloric acid, gelatin, thiourea,

[1] S. Skowronski, "Electro Analysis of Copper," ASTM Bulletin, No. 173, May, 1951, p. 50 (TP104).

[2] Chief of Laboratory, Outokumpu Oy Metalworks, Pori, Finland.

[3] Private information of Baker Platinum, Ltd.

etc., improve the electrolytic copper deposit considerably, especially if a great initial weight is taken. The appearance of deposit thus depends also on the impurities of acids.

If the copper contains considerable sulfur, the sulfuric-nitric acid mixture does not oxidize it completely. One part of sulfur floats on the surface of the electrolyte and causes a deposit of poor appearance. It tends to be spongy and black-streaked.

Insoluble matters such as nickel oxide, metastannic acid, lead sulfate, etc., present in the electrolyte, interfere, especially if agitation is used. Some of the matter is transported to the cathode and the results are therefore high unless the amount of copper absorbed by the precipitate does not compensate the error.

Mr. Skowronski's very interesting information concerning the use of limited amount of nitric acid in the presence of iron makes the use of the slow hydrogen sulfide separation method unnecessary and thus shortens considerably the analysis of copper, ores, concentrates, slags, and mattes. Also the use of oxidizing agents in presence of arsenic and selenium may be generally unknown. The use of manganese nitrate in presence of arsenic and iron however may be complicated because the ferrous iron formed during electrolysis acts as reductant.

The great accuracy of the usual electrolytic determination of copper compared with the other analytical methods is generally acknowledged. The error of 0.015 per cent permitted in the ASTM Method E 53–48[4] is, however, too great for OFHC-copper. In this case a good sample, great accuracy in weighing, avoiding the loss in copper during dissolving and electrolysis, and taking into account the loss in anode are necessary.[5]

[4] 1950 Book of ASTM Methods of Chemical Analysis of Metals, p. 306.
[5] J. Kinnunen, "Determination of Copper in OFHC-copper. Unpublished investigation.

Discussion of Paper on Some Properties of Old-Growth Douglas Fir Decayed by *Fomes Pini*[1]

Mr. E. George Stern.[2]—The author is to be congratulated on the very successful investigation performed by him.

With respect to nailing of Douglas fir, the study confirms the inefficiency of cement-coated nails in comparison with the common, box, and "ring" nails subjected to test. Since there is a decided difference in ring nails of various designs and since the design of the rings along the nail shank is of considerable influence on the nail-holding power both in axial withdrawal and under lateral loading, it is disappointing that a detailed or photographic description of the tested nails is not included in the published paper. On the other hand, some of the "ring" nails made available to the writer indicate that the tested nail is a *barbed* nail, with the barbs impressed on the nail shank, and not a ring-shank or annularly threaded-shank nail with the threads rolled onto the shank in a separate threading operation (see Fig. 1).

Although comparative test data on barbed *versus* annularly threaded-shank nails have been published,[3] a limited number of directly comparative data are presented on axial withdrawal resistance, in pounds, of 2½ by 0.136-in. plain-shank nails, barbed nails used for the Douglas-fir study, and new-type annularly threaded Stronghold nails penetrating for two-thirds shank length into side-grain air-dry (10 per cent moisture content) southern pine of 0.44 specific gravity and tested immediately after driving:

Plain-Shank Nail	Barbed Nail	Stronghold Nail
171	444	487
163	374	450
117	365	420
127	317	459
135	351	413
Average 143	370	446
Average 100%	259%	312%

The preceding data clearly indicate the difference in withdrawal resistance of barbed nails and annularly threaded-shank nails of the Stronghold type.

The author indicates that "the resistance of the nail shank to the shrinkage of the wood around it causes a compression set of the wood, thereby decreasing the nail-holding power." Whether this is a full explanation of the phenomena observed is subject to discussion. Reference is made to a paper which presents detailed data on the influence of deterioration of wood along the steel-nail shank on nail-holding properties.[4] It is obvious that both "compression set" and wood deterioration can be contributing factors to the loss in holding power. The magnitude of each of the two factors will depend upon the test or service conditions under observation. If deterioration is far enough advanced, any compression set is of little if any influence since the deteriorated wood forms a film around the nail shank which acts as a lubricant and, thus, decreases the nail-holding power.

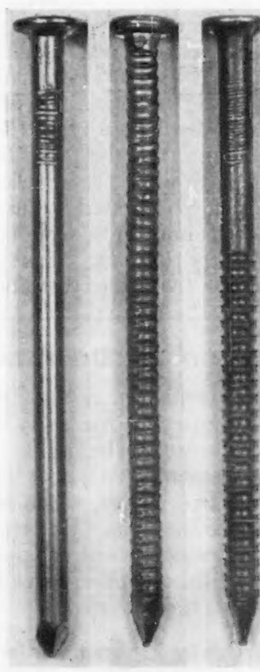


Fig. 1.—From Left to Right, 2½ by 0.136-in. Plain-Shank, Barbed, and Annularly Threaded Stronghold Nails

Mr. J. R. Stillinger (*author's closure*).[5]—Mr. Stern's comments are all well taken. His comment on the correct nomenclature for the nail that I described as "ring" is correct. We bought the nails from a local hardware store which was selling the nail under the name "ring." Mr. Stern has done some excellent work in attempting to classify correctly the many varieties of nails, and I am sure the nail which I called "ring" is a barbed nail. I agree the inclusion of a picture of the nails used would have added a good deal of clarity to the condensed report. The final, comprehensive report contains the picture.

I appreciate Mr. Stern's interest in my paper and think he is doing an excellent piece of work in attempting to standardize the methods of testing the axial withdrawal and lateral resistance of nails. There certainly is a need for a standard testing procedure. For ex-

[1] J. R. Stillinger, "Some Strength and Related Properties of Old-Growth Douglas Fir Decayed by *Fomes Pini*," ASTM Bulletin, No. 173, April, 1951, p. 52 (TP106).
[2] Research Professor of Wood Construction, Virginia Polytechnic Institute, Blacksburg, Va.
[3] E. George Stern, "Nails and Screws in Wood Assembly and Construction," F.P.R.S. Paper 180 presented at the Annual Meeting of Forest Products Research Society, May, 1951.

[4] E. George Stern, "Deterioration of Green Wood Along Steel-Nail Shank and Its Influence on the Nail-Holding Properties," *Virginia Journal of Science*, Vol. 1, No. 3, July, 1950, pp. 200–218.
[5] Chief, Industrial Service Section, Oregon Forest Products Laboratory, Corvallis, Ore.

ample, in designing the experimental work for the nail-holding work included in my report, one of the first difficulties I encountered was deciding what head speed to use in pulling the nails. Previous work, including some of Stern's work, suggested a head speed of 0.05 ± 0.02 in. per min. I was unable to find any reference concerning the effect of head speed on the holding power of nails, so I designed an experiment with the purpose of evaluating the relationship between head speed and holding power (direct withdrawal resistance) of nails. With some 5000 nails to pull, it seemed justified to see if a higher head speed could be used without significantly affecting the average holding power for a particular series of tests.

The results of the test indicated that higher head speeds can be used without significantly affecting the average holding power This test was the basis for using a head speed of 0.5 in. per min instead of 0.05 in. per min. There is a maximum practicable head speed above which one gains very little in saving of total testing time; however, the use of 0.05 instead of 0.5 in.-per-min head speed resulted in a considerable saving in testing time, especially with 5000 nails to pull.

Apparatus for Low-Temperature Tension Tests of Metals*

By Robert J. Mosborg[1]

Synopsis

A brief description of the testing equipment and procedure developed at the University of Illinois for tension tests at low temperature is presented. With the use of a bath of liquid nitrogen for tests at −321 F and a bath of Freon 12 cooled with liquid nitrogen for tests between −90 and −230 F, the testing procedure proved to be both convenient and efficient. The use of a Dewar flask as part of the testing apparatus eliminated additional handling or transfer of the liquid nitrogen and resulted in considerable economy.

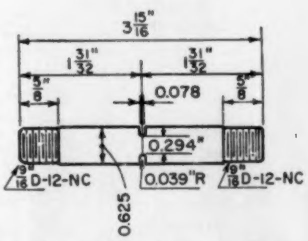
This paper describes apparatus developed in the Structural Research Laboratory of the Civil Engineering Department at the University of Illinois for the purpose of performing tension tests on various types of metal specimens at low temperatures. In the range between room temperature and the temperature obtainable with solid carbon dioxide (dry ice), no special difficulties are encountered, and relatively simple apparatus and procedures can be used.

Temperatures down to −90 F can be obtained with a bath of commercial solvent cooled with dry ice. For the tests at lower temperatures entirely different equipment is necessary. Testing temperatures within the range from −90 to −230 F can be reached with a liquid bath of Freon 12 cooled with liquid nitrogen. For tests at a temperature of −321 F the specimen can be immersed directly in a bath of liquid nitrogen.

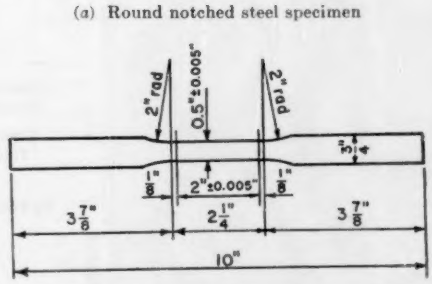
The low-temperature tests for which the described apparatus was developed were conducted under slowly applied static loads. For the duration of these tests, it was necessary that the temperature of the specimen and the bath remain constant. Under these conditions, a method which would make it possible to control the temperature accurately and to change it easily and promptly was required. Also, to conserve liquid nitrogen, the tests required apparatus with sufficient insulation to reduce the conduction losses to the testing machine and to the surrounding atmosphere to a minimum both while the specimen was cooling and during the test.

The apparatus was developed in connection with research programs sponsored by the Materials Branch of the Office of Naval Research and by the Copper and Brass Research Assn. For the former, the program concerned tests of round, notched, steel specimens of the type shown in Fig. 1(*a*). The copper program included tension tests of copper coupon specimens of the dimensions indicated in Fig. 1(*b*). At present tests are being made of similar specimens having a welded joint.

The apparatus was designed by the author working under the supervision of W. H. Munse, Research Assistant Professor of Civil Engineering and under the general direction of N. M. Newmark, Research Professor of Structural Engineering. The apparatus was built in the shops of the Civil Engineering Department.



(*a*) Round notched steel specimen



(*b*) Copper coupon specimen (1/8 and 1/4 in thick)

Fig. 1.—Details of Specimens Tested.

General Description of Equipment

The tension tests were conducted in a 120,000-lb Baldwin-Southwark hydraulic testing machine equipped with spherical seats in both crossheads. The equipment was designed specifically for use with this machine, and a general view of the apparatus is shown in Fig. 2.

The testing chamber is provided by a double-walled sheet-iron container mounted on the lower crosshead of the testing machine. The container is made up of an inner and outer tank, and the space between the tanks is filled with a fine, light, powdery insulating material.[2] The bottom of the outer tank includes a pulling stud which connects to the testing machine crosshead. Another stud, to which the lower pullhead for the specimen is connected, is located in the bottom of the inner tank. The load applied by the testing machine crosshead is transmitted through these pulling studs to the specimen. The two studs, however, are separated by plastic insulating rings which prevent direct contact of the metal in the inner and outer tanks. This reduces the absorption of heat from

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[2] The material used was "Santocel," a product of the Monsanto Chemical Co.

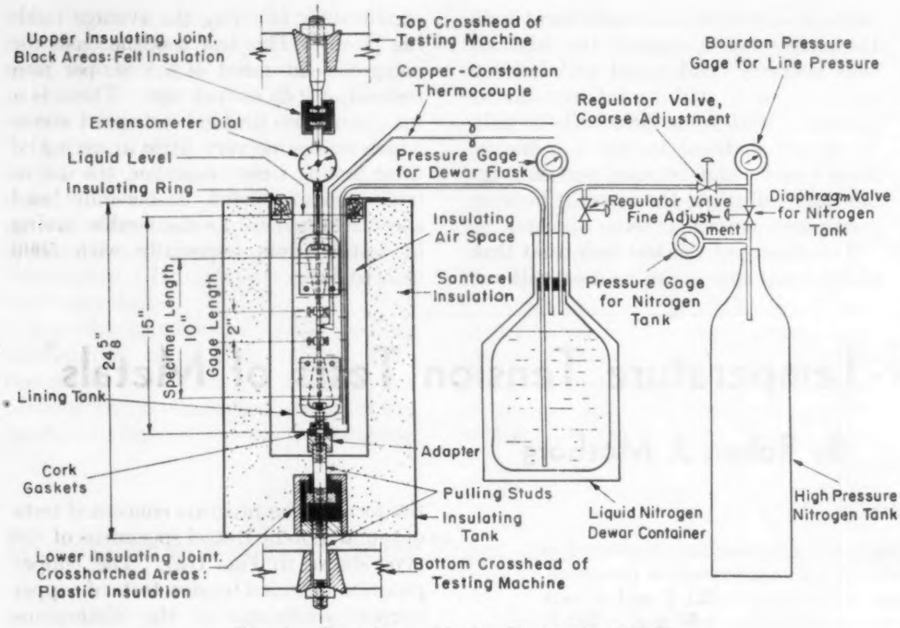

Fig. 2.—Test Assembly for Tests at −321 F.

the lower crosshead and the rest of the testing machine.

Between the testing apparatus and the top crosshead of the testing machine is another insulating joint employing felt insulation. This material proved to be highly satisfactory because it introduced a degree of flexibility which helped reduce eccentricity.

For the tests at −321 F, the pullheads, specimen and testing bath were placed in a lining tank inside the test chamber; the lining tank was surrounded by an insulating air space. Each of the pullheads contained a spherically seated connection so that an axial load from one pullhead to the other was assured. Details of these pullheads are shown in Fig. 3. In conducting tests at temperatures between −90 and −230 F, a helical cooling coil which surrounded the specimen and pullheads was placed in the testing chamber. Figure 4 shows the copper coupon test assembly surrounded by this helical cooling coil.

In the tests it was necessary to obtain a continuous record of the applied load and the accompanying elongation. An extensometer was required that would function satisfactorily when subjected to a variation in temperature from room temperature at its upper end to the testing temperature of the specimen at its lower end. Because of this extreme temperature gradient over a relatively short length, the development of this instrument was rather difficult. Several types of extensometers were tried. Best results were obtained with the double dial device shown in Fig. 3. With this arrangement two 0.0001-in. mechanical micrometer dials, mounted 180 deg apart, gave an average value of the existing elongation. In constructing this extensometer, direct metal contact between the end immersed in the testing bath and the end exposed to room temperature was eliminated by the polystyrene insulating segments. These polystyrene segments were drilled and tapped to match the metal components from each end and effectively prevented the formation of any frost on the dials of the extensometer. This eliminated the sluggish effect of frost action on the dials and enabled them to operate at a temperature only slighty below room temperature.

Liquid nitrogen was obtained in either a 15- or a 25-liter Dewar flask which served a dual purpose: that of a storage container between tests and a dispenser during the test. For use during the tests, a special fitting was developed which sealed the flask and also permitted connections to be made to the other apparatus within the system. This procedure eliminated any additional handling or transfer of the liquid nitrogen.

Additional pressure, to force the liquid nitrogen from the flask, was provided by a 220-cu ft cylinder of gaseous nitrogen. This cylinder was fitted with a pressure regulator which controlled, within 0.5 psi, the pressure of the gas taken from the cylinder.

The temperature of the test specimen was measured by a copper-constantan thermocouple clamped to the specimen. The temperature was recorded continuously with a recording self-balancing potentiometer. There was available also an accurately calibrated portable potentiometer which could be switched into the circuit occasionally to check the

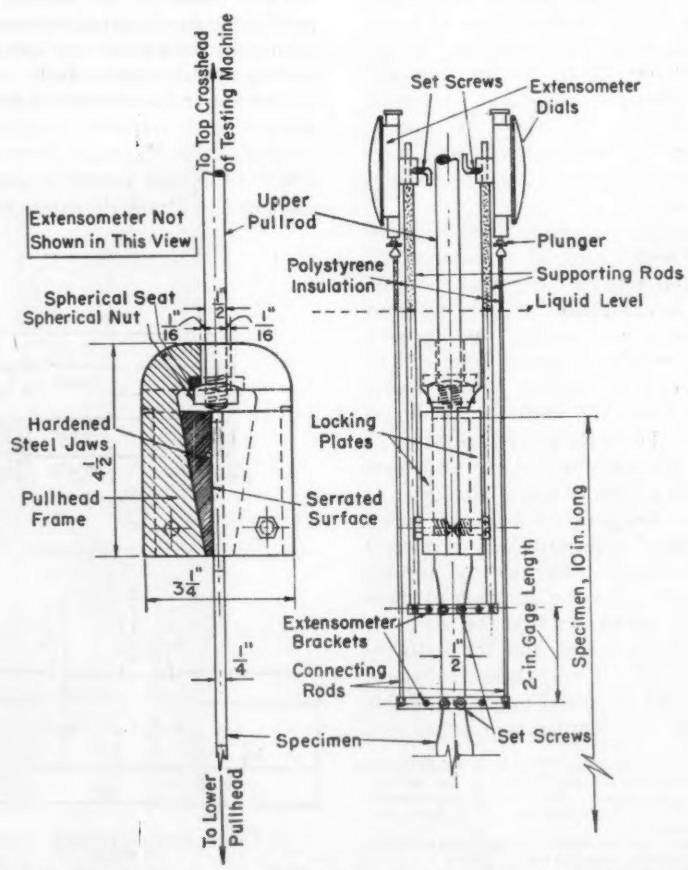

Fig. 3.—Pullhead, Specimen, and Extensometer Assembly for Tests at −321 F.

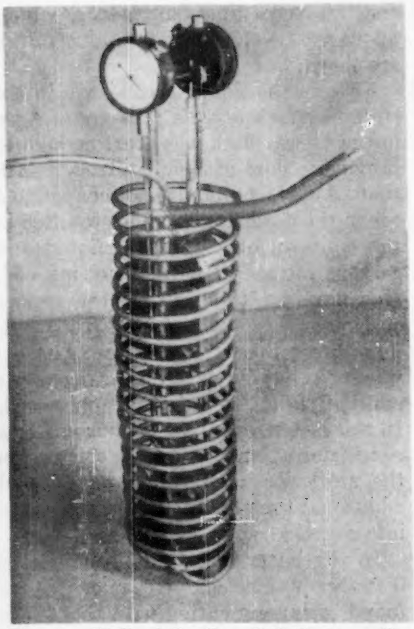

Fig. 4.—Helical Cooling Coil Surrounding Copper Coupon Test Assembly.

recorded temperature. These two instruments were found to be in good agreement at all times.

Discussion of Test Procedure

Operating Principles:

The operation of the apparatus shown in Fig. 2 may be explained as follows. The Dewar flask when placed in this system is sealed so that the liquid nitrogen, in its constantly boiling state, produces a pressure which cannot escape from the container and therefore acts on the surface of the liquid. This seal on the flask permits additional pressure from the cylinder of high-pressure nitrogen gas to be exerted on this liquid nitrogen surface. Also passing through this seal is a $\frac{1}{4}$-in. copper tube which extends to the bottom of the Dewar flask. Because of the constantly boiling state, the liquid nitrogen builds up a pressure over its surface, and this, together with the supplementary pressure from the cylinder of gas, is sufficient to force the liquid nitrogen up through the copper tube and over to the testing chamber.

Since the Dewar flasks are nothing more than large vacuum bottles and are not constructed to withstand any appreciable internal pressures, a pressure gage is installed which indicates the pressure existing above the liquid nitrogen surface. This gage should be read frequently, not only as a safety measure, but also to indicate any change that might occur in the rate of flow.

In a test at a temperature of -321 F, the $\frac{1}{4}$-in. copper tube from the Dewar flask conducts the liquid nitrogen directly into the lining tank, thus forming a liquid bath of nitrogen for the specimen. The liquid nitrogen in this bath is boiling away into the atmosphere constantly. By proper adjustment of the pressure within the Dewar flask, a compensating incoming rate of flow is established and a constant level of liquid nitrogen is maintained in the tank.

For the tests within the temperature range from -90 to -230 F, a combination of liquid nitrogen and Freon 12 is used. For these tests, a helical coil of $\frac{1}{4}$-in. copper tubing is placed in the testing tank. This coil just fits within the tank walls, extends from the top to the bottom of the tank and, with a vertical lead, vents to air. In the tests, liquid nitrogen from the Dewar flask is forced through this copper coil from the top to the bottom. This type of circulation provides the greatest cooling effect where it is needed most—at the surface of the bath. This cools the coil and also, somewhat, the inside of the testing tank. After the tank has been partially cooled, it is filled with liquid Freon 12.[3] This procedure reduces the loss that occurs when Freon 12 is transferred to a comparatively warm container. The liquid nitrogen passing through the coil now cools the Freon bath to the desired temperature.

In passing through this coil, the liquid nitrogen absorbs a considerable amount of heat and vents to the air as a gas. The fastest cooling rate for the bath occurs when this escaping gas changes to a spray. This indicates that the liquid nitrogen has not had sufficient time to absorb enough heat to change completely to a gas. This rate, or any greater rate, of flow is no longer efficient. No attempt is made to collect or retain the gaseous nitrogen which escapes to the air. A photograph of a typical test setup at -230 F is shown in Fig. 5.

Testing Procedure:

The specimen, pullheads, extensometer, thermocouple, and lining tank are carefully assembled, set in the testing chamber, and connected to the proper fittings. The liquid nitrogen is transferred to the testing tank, either directly or through the helical coil, depending upon the testing temperature desired. With a copper-constantan thermocouple clamped to the net section of the specimen, the temperature of the specimen is recorded from the time it is mounted in the machine until it is fractured.

After a specimen reaches the desired testing temperature, it is maintained at

[3] Freon 12 has a boiling point of -18 F and a freezing point of -256 F. Therefore, when not used in a test, it is stored in a refrigerator at a temperature below -18 F.

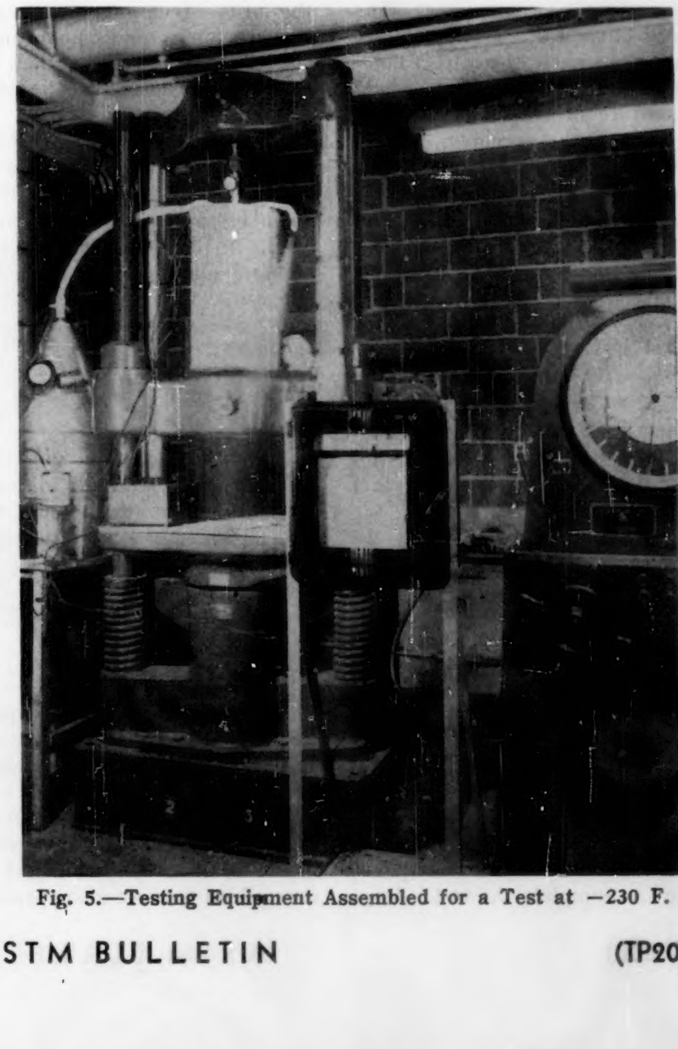

Fig. 5.—Testing Equipment Assembled for a Test at -230 F.

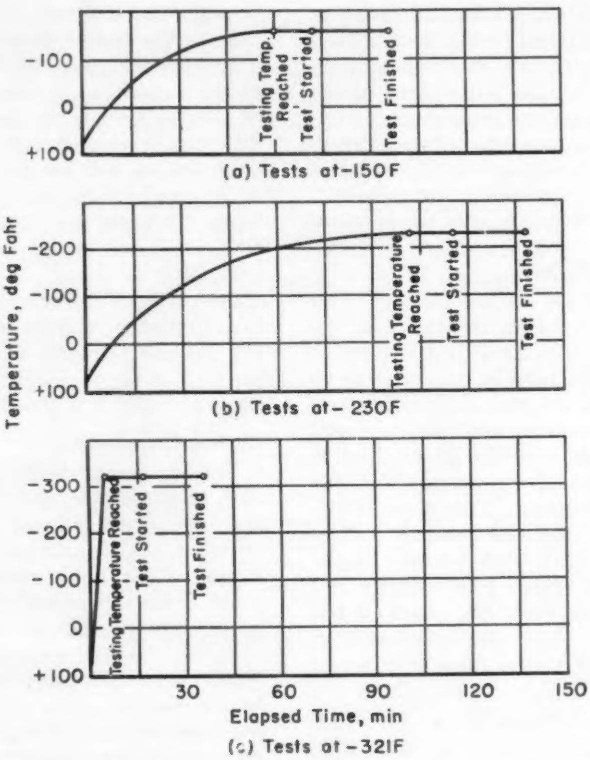

Fig. 6.—Typical Time-Temperature Curves for Low-Temperature Tests.

this temperature for 10 to 15 min before the actual test is started. This time interval reduces the temperature of the pullheads and connections to a value close to that of the test specimen. For tests in liquid nitrogen, the rate of boiling in the bath is greatly reduced when the temperature of the pullheads approaches that of the specimen. Once the test is started, simultaneous readings of load and elongation are recorded at regular intervals until fracture of the specimen occurs.

Upon completion of a test, the specimen, pullheads, extensometer, and fittings are removed from the bath. On exposure to the atmosphere, these extremely cold parts become covered with frost and have a tendency to rust. This rusting is prevented by quickly drying these parts with a warm air blower.

Performance of Tests at −321 F:

The average amount of liquid nitrogen and time required to complete a test at −321 F in each of the two series of tests is given in the following table:

	Time, hr	Amt. of Liquid Nitrogen, lb
Steel specimens...	½	7
Copper specimens	¾	11

In the above tabulation the time required includes that which was necessary to bring the specimen and apparatus down to the testing temperature plus that needed to complete the test. Because of the shorter length of reduced section in the specimen, the tests of steel specimens required less time than the tests of copper specimens. Also, the specimens and apparatus for the steel tests were smaller than those for the copper tests and less liquid nitrogen was consumed.

For tests at −321 F, a slight pressure in the Dewar flask produced a sufficient flow of liquid nitrogen into the testing chamber to maintain the desired liquid level. In these tests the bath was boiling liquid nitrogen; hence the specimen was maintained at a constant temperature of −321 F throughout the entire test.

Performance of Tests Between −90 and −230 F:

The average amount of liquid nitrogen and time required to complete a test at a temperature within the range of −90 to −230 F for each of the two series is given in the following table:

	Time, hr	Amt. of Liquid Nitrogen, lb
Steel specimens....	1	6
Copper specimens..	2	14

Again in these tests the requirements for the steel specimens were considerably less than those for the copper specimens. When the additional losses due to storage, evaporation, and transfer were considered and averaged for all the tests, about 4 lb of liquid nitrogen were added to the consumption of each test. Typical time-temperature curves for tests at −150, −230, and −321 F are shown in Fig. 6.

To cool the liquid Freon bath in the steel specimen tests, a pressure of 4 psi in the Dewar flask was great enough to provide a flow of liquid nitrogen such that all of the liquid did not change to a gas in the cooling coil. This resulted in the emission of a spray of liquid and gaseous nitrogen from the cooling coil. However, for the tests of the copper specimens a pressure of 7 psi (the maximum pressure used in the Dewar flasks) was such that only gaseous nitrogen was emitted from the ¼-in. copper coil. In this latter series, the cooling coil was considerably longer than the coil used in the steel specimen tests and allowed additional time for the liquid to change into a gas.

In the latter tests, a coil of smaller diameter was tried. However, it was found in experimenting with these coils that the larger diameter coil transferred more liquid nitrogen for a given pressure and consequently produced a faster cooling rate within the bath. This resulted in less liquid nitrogen consumed per test and a shorter period of time necessary to complete a test. Probably the consumption of liquid nitrogen and the long testing period could be reduced somewhat by using a ⅜-in. coil.

By proper adjustment of the pressure within the Dewar flask, the deviation of the temperature during a test could be held within ±2 F of the required test temperature.

Summary

The equipment and method outlined in this paper proved to be quite satisfactory for static tension tests at the temperatures indicated and for the types of specimens shown. A sufficient amount of insulation prevented excessive conduction losses and permitted satisfactory operation.

In tests between −90 and −230 F, Freon 12 was used as the cooling bath. Freon 12 was a convenient substance to use since it is inert, nontoxic, does not become gummy or sticky at low temperatures, and freezes suddenly. However, it boils at −18 F, and consequently the liquid had to be stored in a refrigerator when not in use.

This procedure does not furnish testing bath temperatures between −230 and −321 F. Therefore a liquid with a higher boiling point and a freezing point below that of Freon 12 would be desirable and more convenient to use. However, such a material was not readily available.

The use of a liquid nitrogen bath was found to provide an efficient testing medium for tests conducted at a temperature of −321 F.

The Measurement of the Dynamic Modulus of Elastomers by a Vector Subtraction Method*

By C. W. Painter[1]

The measurement of the dynamic modulus of elastomers has received considerable attention for a number of years, for it is widely known that static tests are inadequate for predicting the viscoelastic behavior of elastomers undergoing dynamic flexure. The literature (**1**, **2**)[2] contains several excellent reviews of the various dynamic testing methods in use.

Measurements of dynamic characteristics of elastomers are ordinarily accomplished by use of one of the following three vibratory systems:

1. Forced resonant systems.
2. Systems allowing free vibratory decay.
3. Flexometers or nonresonant forced vibration systems.

A blanket evaluation of these methods is not possible since the desirability of any approach depends largely upon the elastomer being tested and the type of information required. Of the above three methods, the flexometer provides the most direct measurement and allows the simplest control of amplitude and frequency. Despite these relative virtues, flexometers have ordinarily the following disadvantages:

1. The highest flexing frequency obtainable is controlled by the mechanical limitations of the flexing device.
2. The measurement of elastic modulus and hysteresis is normally accomplished by photographing or tracing a hysteresis loop (**3**). This procedure is tedious and time-consuming.
3. Flexometers have not been well adapted for hysteresis measurement in elastomers having low hysteresis.

The equipment described in this paper was developed to eliminate the last two of these disadvantages. Although developed independently, the method bears a resemblance to that employed by Marvin *et al.* (**4**), who performed dynamic modulus measurements on polyisobutylene at very low amplitudes of flexure.

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* Presented at a meeting of Subcommittee XXVII on Tests of Resilience, of ASTM Committee D-11 on Rubber and Rubber-Like Materials, held in Cincinnati Ohio, March 8, 1951.

[1] Research Engineer, Lord Manufacturing Co., Erie, Pa.

[2] The boldface numbers in parentheses refer to the list of references appended to this paper.

A schematic drawing of the apparatus is shown in Fig. 1. The elastomeric test specimen is attached to a horizontal platen which by an adjustable cam arrangement is forced through simple harmonic motion. Measurement of damping and elastic force is accomplished by force and displacement pickups used in conjunction with an amplifier and a vacuum tube voltmeter. The pickups are of similar construction, consisting of thin-walled cylindrical aluminum alloy tubes each of which is equipped with a strain gage. The force pickup is bolted at one end to a fixed structure, and the other end is attached to the inner metal member of the double sandwich test specimen. The displacement pickup can be rotated about its longitudinal axis within a housing which is also fastened to the fixed structure. The other end of the displacement pickup rests against a simple beam spring which is deflected by the oscillating platen. Contact between the pickup and the beam spring is made through a steel ball which insures that only forces normal to the beam will be imposed on the pickup. Both pickups are loaded as cantilever beams and the strain gages are cemented on longitudinally as near as possible to the region of maximum stress. The strain gages form two active arms of a Wheatstone bridge across which is applied an alternating emf of 2000 cps (see Fig. 2). The cyclic strain to which the gages are subjected is proportional to the force applied to the pickups. The variation in the resistance of the gages resulting from the alternating strain produces an amplitude-modulated potential at the amplifier. After amplification, the signal is demodulated and the rms value of the output signal is read with a vacuum tube voltmeter. For certain purposes apparent from further discussion, a dummy strain gage is also provided. By switching, it is possible to substitute the dummy gage in place of the displacement pickup gage.

Before proceeding with modulus and hysteresis measurements, a calibration factor in pounds per volt has to be obtained. This is accomplished by placing a steel spring of known stiffness between the force pickup and the platen in place of a test specimen. The gage selector switch is then positioned to connect the force pickup gage to the dummy gage. With this arrangement,

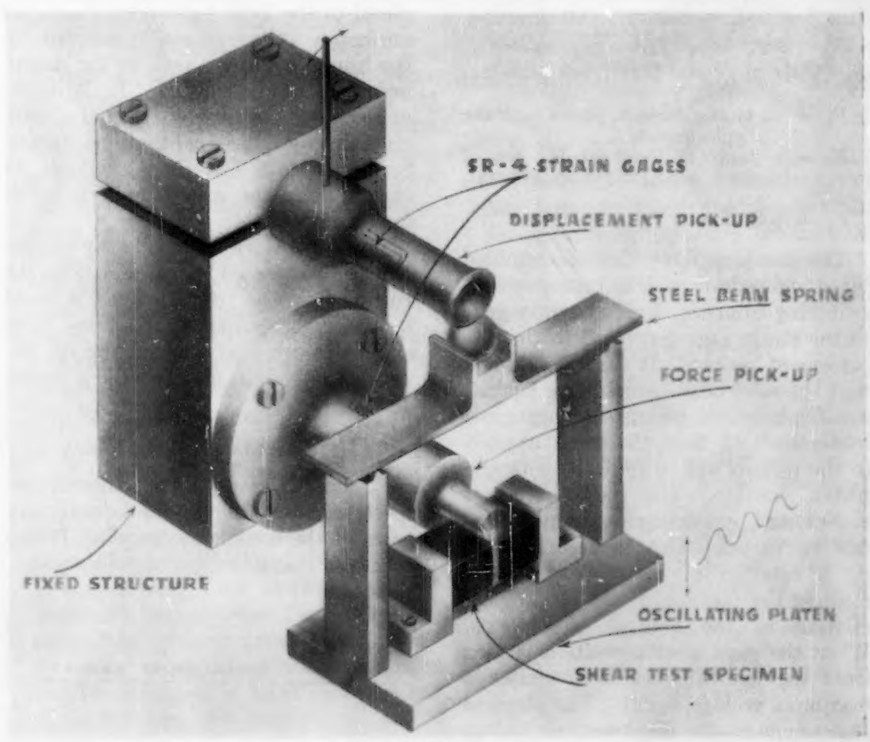

Fig. 1.—Flexometer.

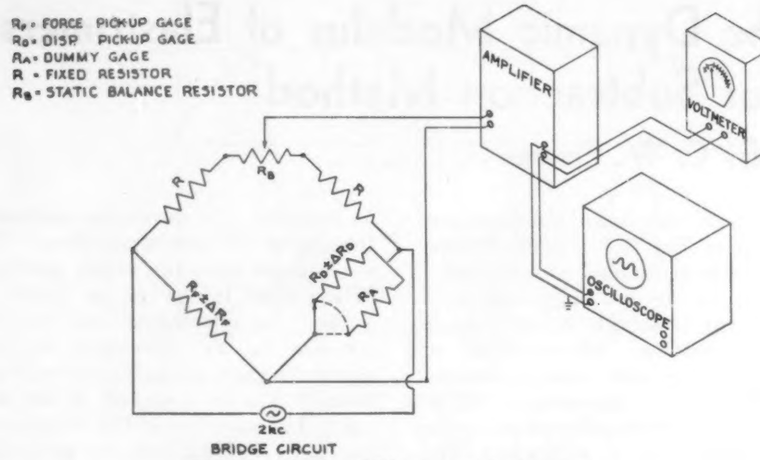

Fig. 2.—Circuit of Measuring Instrument.

only the force pickup gage produces a voltage signal when the platen flexes the steel spring. By measuring the amplitude of platen motion and by reading the voltmeter, it is possible to calculate a calibration factor in terms of pounds applied to the force pickup per volt read on the vacuum tube voltmeter.

The test specimen is then placed in position, and by using the identical electrical arrangement, a measurement of the total force which results from the dynamic flexure of the specimen is made. This force is equal to the vectorial sum of elastic and damping forces generated in the test specimen as shown in Fig. 3. The force relation is expressed by:

$$F_t = \sqrt{(F_s)^2(F_d)^2} \quad \ldots\ldots\ldots (1)$$

or

$$F_s = \sqrt{(F_t)^2 - (F_d)^2}$$

where:

F_s = an elastic force in phase with the displacement,
F_d = a damping force 90 deg out of phase with the displacement, and
F_t = total force.

The damping force F_d is determined by a procedure which first involves switching from the dummy strain gage to the strain gage cemented to the displacement pickup. It can be assumed that the steel beam which rests against the displacement pickup has negligible hysteresis and that the force applied to the pickup will be in phase with the platen motion. The voltage signal contributed by the displacement pickup can be varied. This is accomplished by a rotation of the pickup, which changes the position of the strain gage relative to the neutral strain axis. When the gage is at a position 90 deg from the neutral axis, it generates a maximum voltage signal. The physical dimensions of the displacement pickup and beam are chosen to make the maximum voltage that can be produced by the displacement pickup greater than the voltage generated by the force pickup. As the displacement pickup is rotated and the strain gage passes through the neutral strain axis, the voltage contribution of the displacement pickup becomes zero and then undergoes a sudden 180-deg phase shift since the direction of strain is reversed. *The displacement pickup consequently is used to provide a voltage signal of adjustable amplitude which will oppose directly that portion of the voltage generated by the elastic component F_s acting on the force pickup.* When the displacement pickup is rotated until a minimum voltage output is indicated by the voltmeter, the voltage produced by the displacement pickup is equal and opposite to and cancels the voltage produced in the force pickup by F_s. This minimum voltage signal produced by the bridge is proportional to the damping force component F_d. F_d is determined by multiplying the minimum voltage by the calibration factor. Sufficient data are then available to obtain both the elastic and damping force components.

In all this work a cathode ray oscilloscope is connected in parallel with the voltmeter. The oscilloscope is used to check the purity of the wave form and to insure that the reading on the voltmeter is not affected by external disturbances.

Utilization of Test Data

F_s and F_d can be considered, respectively, as the real and imaginary parts of the complex force, F_t. It can be shown that if

G^* = complex dynamic modulus, psi

then

$$G^* = F_t\left(\frac{B}{X_0}\right)$$

where:

B = shape factor $\left(\frac{1}{\text{in.}}\right)$ = $\dfrac{\text{shear wall thickness}}{\text{shear area}}$, and

X_0 = amplitude of flexure, in.

It follows that

$$G' = \frac{F_s B}{X_0}$$

$$G'' = \frac{F_d B}{X_0}$$

and

$$\frac{G''}{G'} = \frac{F_d}{F_s}$$

where:

G' = real part of dynamic modulus, psi, and
G'' = imaginary part of dynamic modulus, psi.

The ratio G''/G' which is sometimes called the "mechanical dissipation factor," can be used in calculating resilience.[3] For small values of G''/G' Resilience per cent $100\ Xe^{-\pi G'/G''}$:

Figure 4 shows the variation of dynamic elastic shear modulus, G', and G''/G', with dynamic strain. These curves were derived from measurements made on a 47 durometer type W neoprene stock and a 41 durometer silicone stock. Since this paper is primarily concerned with a description of the testing apparatus, a further discussion of test data is beyond its scope.

Accuracy and Range of Equipment

The accuracy of the test data is dependent upon the accuracy of the calibration of the steel spring, the control of the physical dimensions of the test specimen, and the stability and linearity of the amplifier-voltmeter circuit. The error arising from the first two factors is considered to be less than ±2 per cent. The frequency response of the amplifier-voltmeter has been determined by using a steel spring as the flex specimen and recording voltmeter readings throughout the 15 to 60-cps frequency range with the platen amplitude constant. The voltage has been found to be constant within ±0.75

[3] Resilience is defined here as the ratio of amplitudes of two consecutive vibration cycles in a system undergoing free vibration.

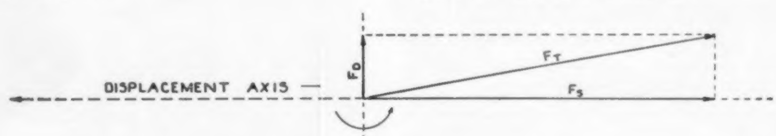

Fig. 3.—Relationship of Forces Measured in Test Specimen.

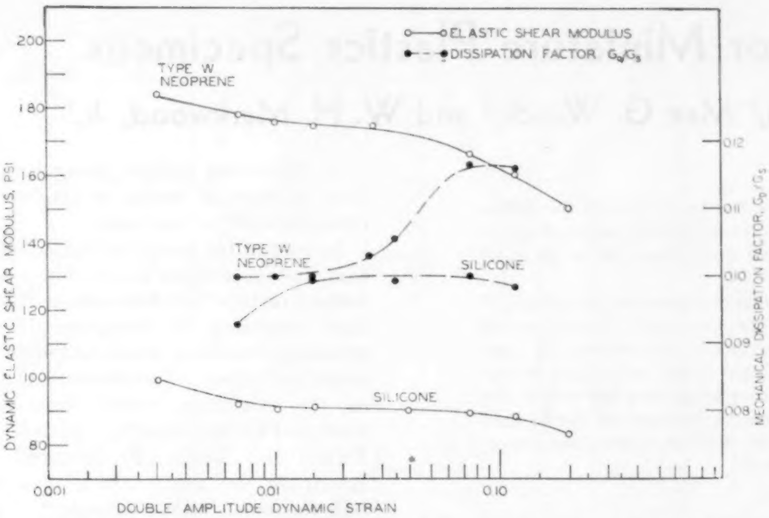

Fig. 4.—Variation of Dynamic Elastic Shear Modulus, G′, and Mechanical Dissipation Factor, G′′/G′, with Dynamic Strain; Frequency: 25 cps; Temperature: 75 F. Mechanical Dissipation Factor Can Be Used in Calculating Resilience.

per cent. The calibration factor as determined by using the same calibrating spring, has been found to be constant within ±1 per cent over a period of months.

The limits of frequency and force for which the apparatus is suited are not established by the test method but by the particular equipment used. The present equipment covers a frequency range from 15 to 60 cps. The lower limit is fixed by the vacuum tube voltmeter and the upper limit by the mechanical limitations of the flexing machine. The minimum force that can be measured is 0.027 lb. Smaller forces could be measured by increasing the sensitivity of the force pickup or by choosing an amplifier with a higher gain. It follows that for a given test specimen there is a limiting flex amplitude below which the force component F_d will be too small to produce a reading on the voltmeter. With the sensitivity now available, sufficient force is generated by specimens which the apparatus can conveniently accept, to permit resilience as high as 99 per cent to be measured. This has been verified by conducting measurements at a flex amplitude of ±0.018 in. on a steel spring having a spring rate of 230 lb per in. These measurements indicated a G''/G' ratio of 0.003 or a resilience of greater than 99 per cent.

The voltage minimum measured for determining F_d will have a true sinusoidal variation only if the test specimen has a linear force deflection characteristic throughout the amplitude of flexure. If the force produced is not a linear function of the displacement, the voltage signal will be composed of a fundamental frequency produced by F_d and of higher harmonics whose amplitudes will depend upon the degree of variance from linearity. Since the displacement is sinusoidal, the higher harmonics do no work and are of no interest except to the extent to which they may affect an accurate measurement of the voltage produced by F_d. The vacuum tube voltmeter used tends to pick out only the fundamental, unless the amplitudes of higher harmonics are appreciable. Wave analyzer measurements made during tests on representative shear test specimens have indicated that the amplitudes of higher harmonics are sufficiently small to make their effect on the voltmeter reading negligible.

The vector subtraction method can be used as described for making measurements on elastomers flexed in compression if the amplitude of flexure is sufficiently small. The considerable nonlinearity which would be encountered at large compressive flex amplitudes would necessitate the addition of a properly designed filter circuit to eliminate the presence of higher harmonics having excessively high amplitudes. The use of a wave analyzer would allow accurate measurements to be made over a wide range of compressive flex amplitude and frequency.

Variation of Test Parameters

The amplitude of flexure is varied by changing the eccentricity of the adjustable cam which drives the platen. It has already been shown that it is necessary to measure flex amplitude as well as force in order to determine dynamic modulus. Platen excursion can be measured in most cases by one of the following devices:

1. Dial indicator.
2. Cathetometer.
3. Displacement pickup.

All three of these have been used in this work, but the displacement pickup has proved to be the most suitable. The pickup is calibrated for displacement measurement by rotating it to the position of maximum sensitivity and reading the resulting voltage produced by the displacement pickup and steel beam alone for a known platen amplitude. The amplitude chosen for calibration is sufficiently large to allow its measurement with a dial indicator or cathetometer within a very small percentage of error. The calibration provides a calibration factor whose units are inches per volt. The displacement pickup can then be used as a highly sensitive displacement indicator which will provide an accurate measurement even at amplitudes less than 0.001 in.

Static shear strain is varied by changing the vertical location of the force pickup relative to the oscillating platen. Static strain normal to the direction of flexure can be varied by changing the position of the outer metal members of the test specimen. Unbonded test specimens can be used if sufficient static compressive strain is applied normal to the direction of dynamic shear strain to prevent slippage of the elastomer relative to the metal surface.

Temperature effects have been investigated by placing the entire flexing apparatus within a temperature control box. The platen was operated by a shaft which extended through an opening to a variable speed drive. This arrangement is also well suited for investigating the change in dynamic modulus brought about by crystallization.

Conclusion

It is felt that the equipment which has been described provides a method for measuring dynamic modulus and hysteresis rapidly and accurately. It also lends itself to convenient adjustment of test parameters.

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An Impact Test for Miniature Plastics Specimens

By Howard W. Woodham,[1] Max G. Wirick,[2] and W. H. Markwood, Jr.[2]

SYNOPSIS

A single-blow falling-weight testing machine has been devised for determining the impact resistance of miniature injection molded, notched specimens of experimental plastics when only small quantities (20 to 50 g) of molding powder are available.

A steel cantilever beam, with the test specimen clamped to its free end, is displaced by the impact blow which fractures the specimen. As a result of this displacement, an emf is induced by the movement of a permanent magnet through a solenoid and recorded as a single trace on a cathode-ray oscillograph. The square of the oscillograph trace height is a function of the energy transmitted to the cantilever and, hence, a measure of the impact resistance of the specimen. By an empiricially derived correlation curve, the result may be converted to ASTM Izod units.

AMONG the criteria for determining the commercial value of an experimental polymer is a knowledge of its physical properties. Equipment, time, and cost limitations often prevent the production of more than 100 g of an experimental polymer. Usually only a part of this is available for physical properties testing. Methods have been devised for determining tensile, flexural, and hardness values on miniature plastics specimens employing the same equipment used for standard ASTM specimens, but the Izod pendulum impact machine was found to be impractical for breaking miniature (0.1 by 0.2 by 1.4-in.) specimens of many of the tough, commercial thermoplastics. The reduced cross-sectional area of the small bars compared to that of regular test pieces (0.5 by 0.5 by 2.5 in.) greatly increases their flexibility, resulting in only partial fractures except among the most brittle formulations. Also, the energy required to break miniature specimens is too low to be accurately recorded on even the lowest capacity Izod machines.

LIMITATIONS OF PRESENT IMPACT TESTERS

The demand has long been felt for equipment capable of determining the impact resistance of miniature plastics specimens. Bailey and Ward (**1**)[3] have used a "ski ball" apparatus similar to that of Stock (**2**), subtracting the residual energy of the ball after specimen fracture from the kinetic energy of the ball at the point of impact. This type of tester is satisfactory for relatively brittle materials, but miniature specimens of the tougher plastics only flex under dynamic impact loading.

The machines described by Church and Daynes (**3**) and Callendar (**4**), in which calibrated weights are dropped upon specimens supported as simple beams, are unsatisfactory for the same reason. Added disadvantages of this type of equipment as well as of the falling-weight, rapid-compression apparatus of Charlton and Farmer (**5**) are the following:

1. The mass of the minimum breaking weight must be determined by trial and error, making the test time consuming.

2. Since some thermoplastics are subject to severe fatiguing by repeated impact, as pointed out by Telfair and Nason (**6**) and others, numerous specimens, requiring more than a minimum amount of material, must be used if valid results are expected.

3. Specimen failure, defined as the first perceptible crack or fracture, is often difficult to recognize.

In view of the foregoing, an investigation was undertaken to develop a satisfactory method for determining the impact resistance of miniature plastics specimens, whether brittle or tough, in a single operation. Furthermore, in spite of the criticisms which have been leveled at the Izod test[4] by Callendar (**4**), Telfair and Nason (**6**), Maxwell and Rahm (**7**), and many others, since it is still the most widely accepted impact method, an additional objective was to convert the test results into Izod units.

DESCRIPTION OF TESTER

No attempt is made in this paper to enhance the present theoretical knowledge of impact testing or to refine the Izod method. It is believed, however, that the machine described below provides a practical means of quickly and easily estimating the impact resistance of miniature plastics specimens.

The tester, sketched schematically in Fig. 1, is of the single-blow, falling-weight variety. The hollow cylindrical striker (weight, 1.6 lb) fits closely around, but does not bind on, the vertical guide shaft (clearance, 0.003 in.); when released, it moves downward with

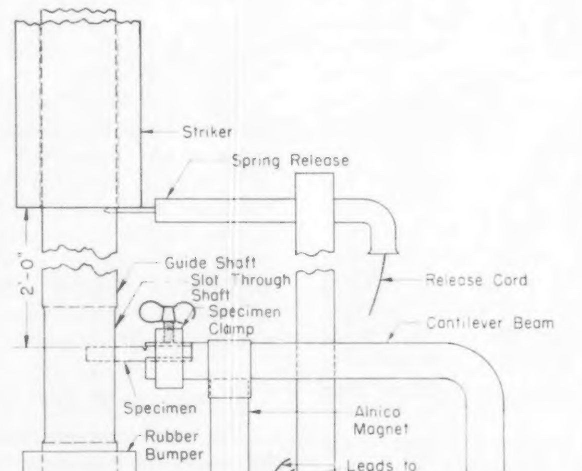

Fig. 1—Schematic Diagram of Tester.

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[1] Hercules Powder Co., Cellulose Products Plant, Hopewell, Va.

[2] Hercules Experiment Station, Hercules Powder Co., Wilmington, Del.

[3] The boldface numbers in parentheses refer to the list of references appended to this paper.

[4] Tentative Methods of Test for Impact Resistance of Plastics and Electrical Insulating Materials (D 256 - 47 T), 1949 Book of ASTM Standards, Part 6, p. 131.

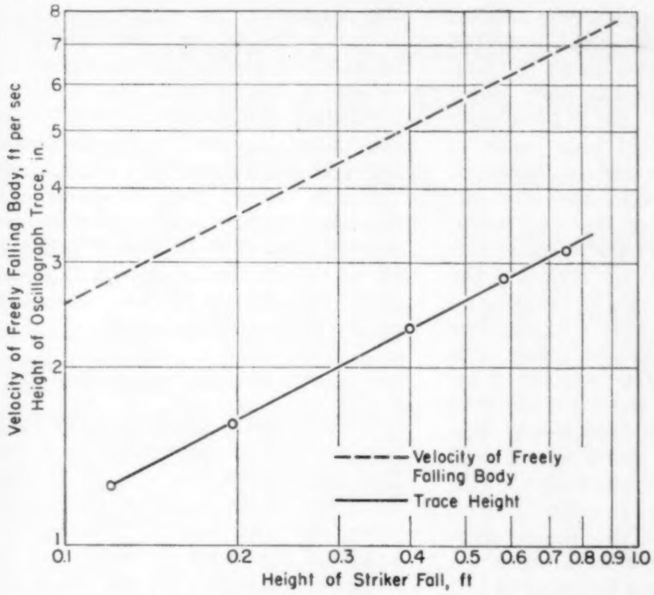

Fig. 2—Correlation of Oscillograph Response with Striker Velocity.

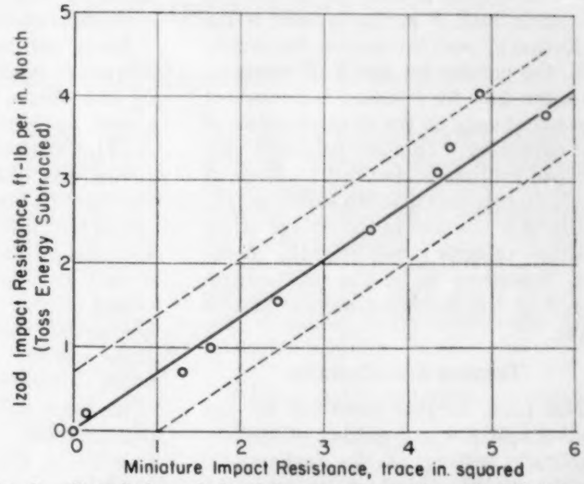

Fig. 3.—Correlation of Izod Impact Strength with Miniature Specimen Test Results Showing 95 per cent Confidence Limits.

the characteristics of a freely falling body, traveling a distance of 2 ft and attaining a velocity of approximately 11 ft per sec before contacting the test specimen. After the specimen has been fractured, the excess energy of the striker is absorbed by a soft rubber bumper.

The miniature plastic specimen is notched (with the same milling cutter recommended by ASTM for Izod samples) to a depth of 0.04 in. through the 0.2-in. dimension at a distance of $\frac{5}{8}$ in. from one end. This end is clamped to the free end of the steel cantilever beam with the notched edge up and the notch apex directly over the free end of the cantilever. The opposite end of the specimen extends into a slot cut in the guide shaft. The impact blow is struck on the outer edge of the notch, just 0.03 in. beyond the end of the steel beam.

For support, the steel cantilever is bent at right angles and securely bolted to the heavy base plate of the apparatus. Attached to the underside of the steel beam near the specimen clamp is an Alnico bar magnet which dips vertically downward into a hollow coil of wire whose terminals are connected to the Y-input of a DuMont 304H cathode-ray oscillograph equipped with a long persistence screen.

During an actual test, the energy required to break the test specimen is transferred to the steel cantilever, causing it to be deflected rapidly downward. With the specimen severed, the beam is free to vibrate, and as it passes upward through its normal neutral position from its point of maximum deflection (a travel of a few thousandths of an inch at most), its velocity is a maximum. At this instant, the maximum emf, induced by the movement of the magnet through the coil, is recorded on the oscillograph. The height of the trace above the positioned zero point can be read visually, and this value can be converted to the approximate Izod equivalent by means of a correlation curve, as explained later in this paper.

The advantages of this equipment for measuring the impact resistance of small test specimens of plastics include the following:

1. The specimen is always completely broken through its cross-section at the notch with no partial fractures or hanging "skins" to complicate the result. Although the type of failure encountered in this test is largely one of shear, as compared to the tension-compression stresses encountered in the Izod test, it is felt that this is no particular disadvantage since a satisfactory correlation can be effected.

2. The energy imparted to the free end of the broken specimen (end effect) is of no consequence since the residual energy of the striker is not considered.

3. The energy transmitted to the tester base through the cantilever before the maximum emf has been recorded is a constant fraction of the total; hence, machine losses are of no consequence.

4. An impact test value may be obtained on a single specimen, although at least five check determinations are preferred, as in the Izod test.

Energy Analysis

No attempt has been made to develop a rigorous energy analysis of the operation of the miniature impact tester, as the primary objective of this development was to make possible the correlation of impact test values on miniature specimens with Izod results on standard samples, and the simplest way to accomplish this objective was by means of a correlation curve. However, it can be shown that the trace heights developed on the oscillograph are functions of the maximum velocity of the displacement of the cantilever (that is, of the magnet within the solenoid).

This can be demonstrated very readily by substituting a metal bar for the miniature plastic specimen, connecting the coil leads so the oscillograph responds to the emf generated by the *downward* motion of the cantilever, and then dropping the striker on the metal bar from several measured heights. Figure 2 is a plot of typical data obtained in this manner; it is apparent that oscillograph response is a linear function of displacement velocity, since both are the same power function of the height of striker fall (that is, the two lines are parallel).

In the normal operation of the tester, the coil leads are reversed so that the oscillograph records the emf generated by the *upward* motion of the cantilever. Since the maximum speed of the beam recovery is a function of its displacement only, the trace height is not affected by any action or reaction of the specimen in breaking, such as would influence the initial downward displacement.

Discounting machine losses, the potential energy stored in the cantilever at the point of its maximum deflection downward is equal to the energy required to fracture the test specimen. If the actual displacement of the end of the beam from its neutral position is d, and the force required to achieve this deflection in static loading is P, then the

stored energy is equal to one-half the product of P and d. But each of these quantities can be related to the maximum velocity of recovery, as the greater the static load P is, the greater is the deflection d; and the greater the deflection, the greater the speed of recovery, since the time for recovery is a constant dependent only on the characteristics of the cantilever. (Simple harmonic undamped motion is assumed.) Thus, it would be expected that the stored energy would be a function of the square of the recovery velocity (trace height). Actually, this seems to be the case, as discussed in the following section of this paper.

Testing and Results

The trace heights recorded by the oscillograph are a function of the Y-amplitude setting of the instrument. For the majority of the tests described herein a setting of 50 was used (with the Y-attenuator ac amplifier maintained at 100). Occasionally it is necessary to use some other setting for unusually tough or brittle materials. For such cases the readings obtained are converted to the Y-amplitude 50 equivalents. The conversion is accomplished with the aid of calibration values like those listed in Table I.

TABLE I.—Calibration Oscillograph Trace Heights for Various Y-Amplitude Settings.

Y-Amplitude Setting	Trace Height Induced by 2⅜-in. Fall of Striker on Metal Bar, in.
10	0.20
20	0.39
30	0.68
40	1.02
50	1.42
60	1.90
70	2.32
80	2.70
90	3.03
100	3.27

These values were obtained with the aid of a metal bar in place of the test specimen, using the technique employed in studying the velocity-response characteristics of the tester (see "Energy Analysis"). Calibrations were made periodically as a check on the stability of the magnetic-electrical indicating system.

The data used to establish the correlation between impact strength values on miniature specimens (as measured by the apparatus described herein) and on regular ASTM specimens (as measured with a 50 in-lb capacity Izod tester) included results on nine different thermoplastic compositions. All test samples were injection molded[5]; the miniature specimens were notched and tested according to the procedure previously outlined, while the Izod bars were notched and tested as recommended in ASTM D 256 - 47 T.[4] From 12 to 75 specimens of each formulation were tested by both methods.

Since the results of tests made on miniature specimens are not influenced by end effects, all Izod values were corrected by eliminating the toss factor. An approximation of the value of this factor was obtained by replacing the free end of a broken sample, following an actual test, and striking it a second time with the pendulum in such a way as to impart to it the same velocity it attained during the test. In order to accomplish this, the Izod testing machine was provided with a second scale which calibrated its backswing in terms of the same units used in subdividing its regular scale. Using this second scale as a guide, the height from which the pendulum was released was reduced to a value equal to the height to which it rose during the test. The energy to toss was then considered to be the difference between the reading obtained as described above and the original reading following the breaking of the test specimen.

Test results listed in Table II were treated statistically to determine variances, standard deviations, corrected means, and confidence limits. The 95 per cent level of probability was consistently used in these calculations; both Izod and miniature values have been rounded to the nearest 0.05 unit. A tenth correlation point corresponding to a zero value on both testers was also considered valid.

TABLE II.—Correlation of Izod and Miniature Impact Data.

Plastic	Izod Impact Strength, ft-lb per in. notch[a]	Miniature Impact Resistance,[b] (trace height)[2]
Polystyrene	0.20	0.15
Modified styrene copolymer	0.70	1.30
Nylon	1.00	1.65
Cellulose acetate No. 1	1.55	2.45
Cellulose acetate No. 2	2.40	3.35
Cellulose propionate	3.10	4.35
Cellulose acetate butyrate	3.40	4.50
Ethyl cellulose	3.80	5.65
Cellulose acetate No. 3	4.05	4.85

[a] ASTM Method D 256 - 47 T with toss energy subtracted.
[b] Units here are inches squared and are not directly convertible to Izod units by dimensional analysis.

From the data of Table II, a regression line was calculated with each point weighted in accordance with the number of Izod and miniature specimens used to obtain it. The correlation coefficient was found to be virtually 1.0, indicating the validity of the linear relationship between Izod results and the square of the oscillograph trace heights. The 95 per cent confidence limits calculated for the line are shown on either side of it in Fig. 3. It is interesting to note that almost 70 per cent of the magnitude of the confidence limits is contributed by a single point (cellulose acetate No. 3, Table II). Inasmuch as there is no valid reason for rejecting this point, it must be included. However, additional data on this and other formulations should materially narrow the confidence limits.

Conclusions

With as little as 20 g of molding powder, a close approximation of the Izod impact resistance of a plastic can be obtained with the aid of the impact tester described herein. The equivalent Izod values are corrected for the energy lost in tossing the free end of the broken test specimen. As in Izod testing, at least five check determinations are recommended for an average impact resistance value, although estimates can be made from single specimens, since clean breaks occur with each piece. The test can be performed as rapidly as the Izod.

The possibility of designing a larger version of this miniature tester to handle standard ASTM specimens is obvious. It is realized, however, that the energy relationships involved will have to be understood in more detail before test results on ASTM specimens can be expressed in energy units.

Acknowledgment:

An expression of appreciation is made to P. I. Donnelly for his assistance in the design and construction of this apparatus.

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[5] Miniature samples were made on a hand-operated machine, the Plasticor Junior, Model A, formerly manufactured by the N.R.K. Mfg. and Engineering Co., and now sold by the Simplomatic Mfg. Co., Chicago.

De-aired, Extruded Soil Specimens for Research and for Evaluation of Test Procedures*

By Hudson Matlock, Jr., Carl W. Fenske,[1] and Raymond F. Dawson[1]

Importance of Uniform Specimens

In many research programs a testing procedure is used that requires parallel or duplicate testing of what, it is hoped, are identical samples. Frequently, the lack of uniformity of the samples produces considerable scattering in the results obtained. To overcome this objection it is sometimes necessary to repeat tests many times so that sufficiently accurate average values can be obtained. The procedure described in this paper gives the techniques for preparing remolded specimens that will have uniform density and moisture throughout the specimen, with virtually no entrapped air.

Much of the early basic research in the field of soil mechanics was performed on remolded soils, but later investigations showed that the remolded specimens did not behave in the same manner as the undisturbed soils. Because of the nonuniformity of undisturbed clays, many laboratory investigations still employ remolded samples, and the ideas thus developed are interpreted with consideration for the effects of the remolding. The laboratory preparation of remolded specimens usually follows one of two procedures: (1) soils are molded at or slightly above their liquid limit, with or without the use of the vacuum to eliminate entrapped air; or (2) soils are molded at some lower moisture content by compression or compaction into molds. These specimens have the disadvantage of nonuniformity because of uneven compaction, entrapped air, and uneven moisture content throughout the specimen, or else have exceedingly high moisture content.

While the uniform specimens prepared by the extrusion process at The University of Texas are not intended to replace undisturbed soils nor to do away with the necessity of taking undisturbed specimens for design purposes, they do simulate the undisturbed soils and may be used for many laboratory investigations where a large number of uniform samples are required or for checking testing techniques where uniformity of the sample is essential.

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Development of Extruded Samples

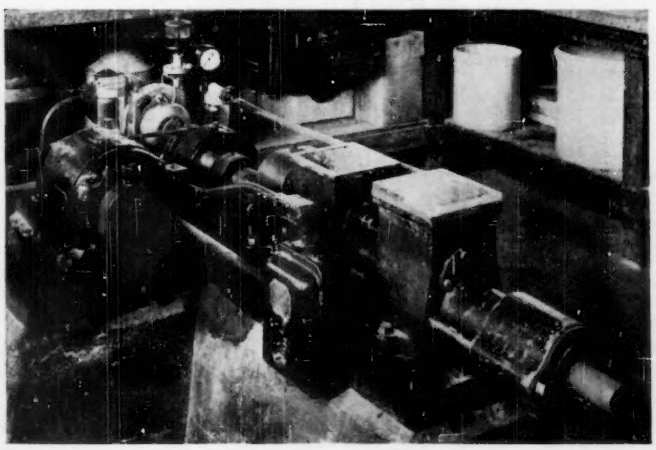
Early in 1941, a block of raw, extruded, de-aired clay was obtained from a brick manufacturing plant in Austin, Tex., to be used for a series of consolidation tests. This was followed by additional work on similar materials and also on sections from raw clay tile which were prepared in the same manner as the brick slugs. The results of tests on these samples were only fairly satisfactory, and therefore a search was made for a means of preparing the remolded samples under close laboratory supervision. The Ceramic Engineering Department at The University of Texas has a small experimental-type extrusion machine for the preparation of de-aired samples. This machine could be adapted to produce slugs up to 3 in. in diameter and was used to produce specimens for this investigation. Larger specimens would have been desirable, especially for consolidation tests, but no machine was available to produce larger specimens.

Preparation of Extruded Slugs

The Extrusion Device:

A Vac-Aire "Experimental" Extrusion machine, manufactured by the International Clay Machinery Co., was used for the preparation of the extruded slugs. A photograph of the device and a simplified sketch, prepared from the manufacturer's working drawing, are shown in Fig. 1. The device consists essentially of a pair of augers, 3.1 in. in diameter, in tandem, driven by a 1-hp electric motor, which pass successively through two identical cast iron housings. The upper portion of the first housing serves as a hopper for charging the machine. A vacuum of 25 in. of mercury is applied to a second chamber, which is covered by a heavy glass plate placed on a moistened rubber gasket. Along the auger, the vacuum seal is maintained by the clay itself.

The material fed into the hopper is caught by a roller, which kneads it into the auger. The auger then forces it through small openings into the second chamber. Extrusion of the clay into the second chamber in small ribbons allows bubbles of entrapped air to be distended and broken. The clay continues to move through the second chamber until it enters the heavy cylinder which supports the die at the end. The portion of the auger which extends into this forming throat has a variable pitch, the pitch decreasing toward the die so as to build up a high pressure for



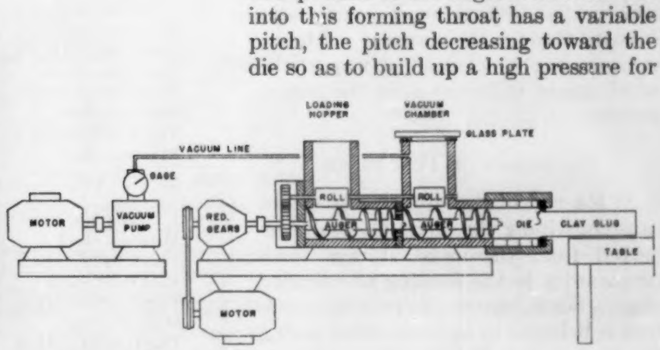


Fig. 1—Vac-Aire "Experimental" Extrusion Machine.

(*Courtesy of the International Clay Machinery Co.*)

forcing material out in the desired shape. Because clay cannot be extruded successfully with a cross-section larger than the diameter of the auger, the diameter of the special die which was made for the preparation of the test specimens was limited to 3 in.

Preliminary Sample Preparation:

The soil selected for the preparation of extruded samples and for subsequent consolidations and unconfined compression tests was a yellow calcareous clay from a new highway cut near Austin Tex. The clay had been excavated from a depth of about 15 ft. It was found to have a liquid limit of 47 and a plasticity index of 26. All of the material was finer than 0.5 mm and approximately 50 per cent was finer than 0.005 mm.

A sample of the clay, in the form of hard clods and lumps, was air-dried and then crushed to pass a No. 10 sieve, after which it was thoroughly shovel-mixed to insure uniformity. Sufficient water was added to four separate 100-lb batches of the clay to bring the moisture content up to 24 per cent of the oven-dry weight. This material was used to extrude slugs of series A, intended primarily for unconfined compression test studies. Enough water was added to a fifth 100-lb batch to bring its moisture content up to about 31 per cent which had previously been determined to be nearly the maximum moisture content at which samples of this clay could be successfully handled and stored after extrusion. This material was used for slugs of series B, intended primarily for consolidation test studies.

Each batch was thoroughly mixed in a Lancaster Type Sk G countercurrent concrete mixer. A period of about ten minutes was required for mixing each batch.

The wet material of each 100-lb batch was stored separately in a new 24-gal galvanized garbage can for a period of about one month in a moist storage vault. The intended purpose of this period of storage was to allow the moisture to become more evenly distributed through the material and to aid in softening any small dry particles which might still exist after the mixing process.

Extrusion of Test Slugs

At the end of the storage period, the cans containing the moist clay were removed from the moist storage vault preparatory to the forming of extruded slugs. Some change in moisture content is believed to have occurred during the storage period because the cans were not sealed, and some condensation was observed inside the cans.

For the unconfined compression tests, it was desired to have a large number of specimens with uniform moisture content and degree of saturation. Before forming the slugs, all of the material originally mixed at 24 per cent moisture (series A) was first extruded through a 1-in. square die and cut into lengths of about 15 in. This preliminary extrusion was intended to provide additional mixing and to increase the degree of saturation by the extra exposure to the vacuum. Handfuls of clay for charging the hopper were taken in succession from each of the four cans in an attempt to insure a more uniform moisture content throughout the supply of specimens. To equalize further the moisture content, it was intended that the lengths of 1-sq in. ribbon be fed back into the machine in pairs and a systematic scheme of stacking them was employed to "cross-mix" the material. Unfortunately it was found in making the final extrusion run that it was not practical to feed the ribbons back in pairs as planned. Between the extrusion runs the material was kept in galvanized pans and covered with damp cloths. The 3-in.-diameter slugs were cut off in lengths of 9 to 15 in. as they were forced from the die onto a smooth metal-top table.

While the clay was probably very thoroughly mixed locally from point to point by the extrusion machine, there was little opportunity for smoothing out variations in moisture content occurring at greater intervals. It is believed that while the procedure employed gave fairly consistent average moisture contents from beginning to end of the run, it probably did not aid in eliminating variations from specimen to specimen. It will be seen later that there was some variation in specimens taken at random from the A series of slugs.

The preparation procedure for the clay mixed at a moisture content of 31 per cent (series B) was essentially the same as that described above, except that all the material could be mixed in a single batch and stored in one garbage can.

The 27 slugs formed from this batch were numbered with aluminum tags in the order of their extrusion. Since only a small amount of material was needed, only the first three slugs were used for the consolidation tests. The minimum moisture content observed in these three adjacent slugs was 31.0 per cent while the maximum was only 0.3 per cent greater (see Table I).

The waterproofing procedure for slugs of both series was essentially the same. One coating of paraffin was immediately applied by completely immersing the slugs in molten paraffin. Additional coatings of paraffin and cheesecloth were applied later. It had been noted previously that paraffin applied with a brush had a white color due to entrapped air bubbles and did not effectively seal specimens for long periods of storage in a moist vault. For this reason, all coverings were formed by alternately dipping the

TABLE I.—DATA FROM THREE CONSECUTIVE SLUGS.

Sketch of Slug	Unit Weight, g per cu cm	Observed Moisture, per cent	Average Moisture for Calc., per cent	Calculated Void Ratio	Calculated Saturation per cent
Slug No. 1					
Moisture check		31.19			
TEST SPECIMEN	1.921		31.04	0.876	97.5
Void ratio check	1.923	31.00	31.04	0.875	97.6
TEST SPECIMEN	1.922		31.04	0.876	97.5
Moisture check		30.97			
—Waste—					
Slug No. 2					
Moisture check		31.22			
TEST SPECIMEN	1.917		31.2	0.883	97.2
Moisture check		31.32			
TEST SPECIMEN	1.914		31.2	0.886	96.8
Void ratio check	1.920	30.98	31.2	0.879	97.5
TEST SPECIMEN	1.921		31.2	0.879	97.5
Moisture check		31.25			
TEST SPECIMEN	1.920		31.2	0.879	97.5
Moisture check		31.15			
—Waste—					
Slug No. 3					
Moisture check		31.21			
TEST SPECIMEN	1.921		31.2	0.880	97.6
Void ratio check	1.921	31.19	31.2	0.879	97.6
TEST SPECIMEN	1.922		31.2	0.878	97.8
Moisture check		31.20			
TEST SPECIMEN	1.920		31.1	0.878	97.5
Moisture check		31.00			
—Waste—					

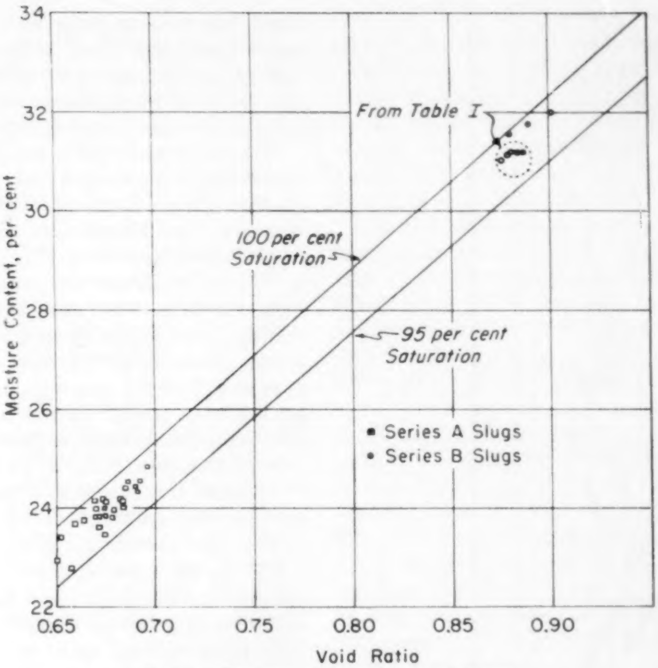


Fig. 2—Degree of Saturation of Slugs.

specimens in a vat of hot paraffin and wrapping them with single layers of cheesecloth.

When freshly extruded slugs were bent or twisted till they ruptured, an internal structure formed by the auger was evident. A definite swirl was seen in the pattern of the rupture cracks. It was feared that this might have some effect on the physical characteristics; therefore, the slugs were stored in the moist storage vault for a period of about one month before use. After this period, the structure was not evident in slugs which were distorted, but some of the structure reappeared when the specimens were dried and shrinkage cracks tended to form along the swirl surfaces. These shrinkage surfaces were clearly evident even in specimens which had been previously subjected to a complete consolidation test. There was no evidence encountered which indicated that there were any detrimental effects on test results due to these surfaces.

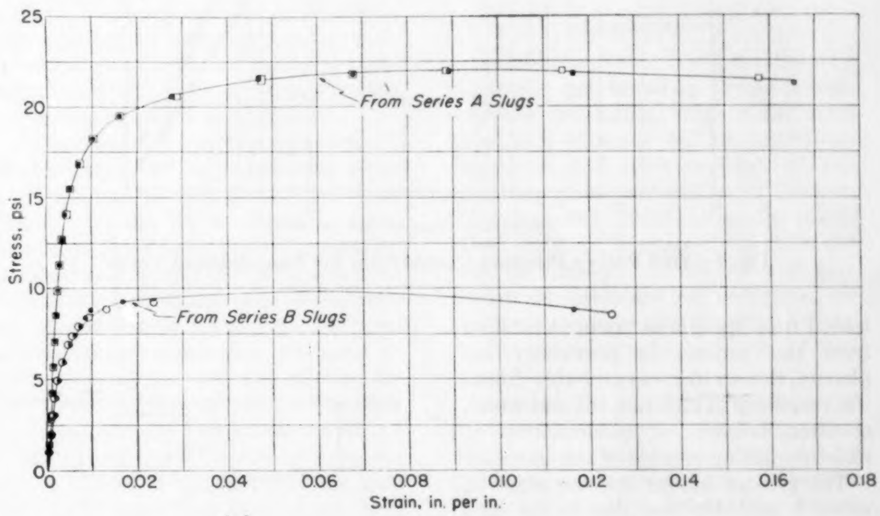
Evaluation of the Extrusion Method

Uniformity of the Slugs:

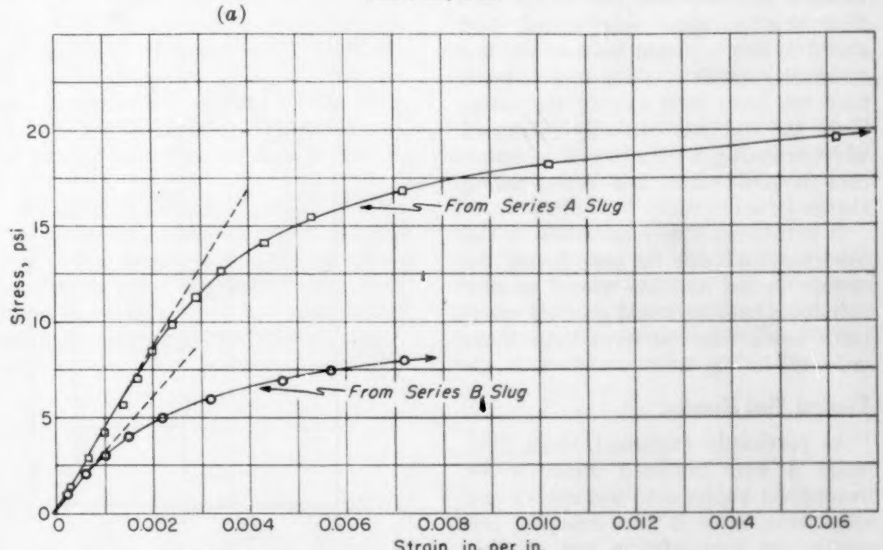
Table I shows in detail the results of moisture and void ratio determinations on the three adjacent slugs of series B which were used for the consolidation tests. The void ratio checks were made by paring sections of the slugs into consolidometer rings.

Extreme care was exercised in the calibration of test rings and in the paring of the samples to insure complete filling of the rings. An analysis based only on the precision of weighings and calibrated test ring volumes revealed that the following errors might be reasonably expected in the test results: percentage of moisture, ± 0.1; void ratio, ± 0.002; and percentage of saturation, ± 0.3. From Table I it is seen that in only two cases were these expected variations exceeded. The exceptions will be noted for the first two determinations from slug No. 2 and may well have been due to incomplete filling of the consolidometer rings. Thus, even with very careful laboratory measurements it is not possible to state that there were any significant differences found in the three consecutive slugs.

Moisture content, void ratio, and degree of saturation data for all of the specimens tested are shown in Fig. 2. The data of Table I for the specimens of series B are included in this plot. It will be seen that these points fall very close together. However, there is considerably more scatter in the results ob-



(*a*)



(*b*) Enlargement of the initial portion of the curves.

Fig. 3—Typical Stress-Strain Relations from Unconfined Compression Tests.

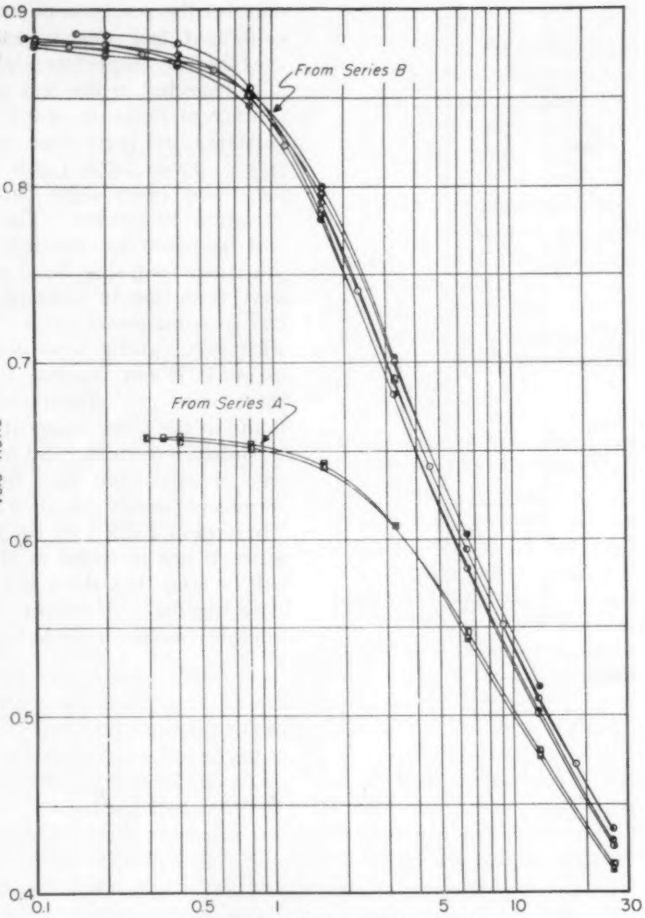


Fig. 4—Void Ratio - Pressure Curves from the Consolidation Tests.

tained from specimens taken at random from this series. As previously explained, this scatter was probably due to the variations in moisture content which occurred because of condensation of moisture during storage of the batch.

The greater scatter for the slugs of series A probably was due to the fact that this material was mixed and stored in four separate batches and the moisture content of these four batches may not have been exactly the same. Since the soil was virtually saturated when extruded, a variation in moisture content would result in a corresponding change in void ratio.

It is believed that elimination of the condensation inside the cans during the storage period and the use of smaller individual batches would produce specimens much more uniform than those indicated in Fig. 2.

Typical Test Results:

As previously explained, slugs from series A were intended primarily for unconfined compression test studies and slugs from series B were intended primarily for consolidation test studies. However, some specimens from series A were tested in consolidation, and unconfined compression tests were made on some specimens from series B. One purpose of both sets of tests was to show the degree to which test results could be duplicated, using extruded slugs.

Typical stress-strain relations from unconfined compression tests are shown in Fig. 3(*a*). Each of the curves is drawn as a graphical average of two sets of plotted data points. The individual tests were made on each of two specimens cut from consecutive slugs and are distinguished in the figure by using different symbols for the plotted points. It is seen that the two tests in each pair are in almost precise agreement. Figure 3(*b*) is an enlargement of the initial portion of the curves shown in Fig. 3(*a*). This figure is included to emphasize the linear characteristic of the initial portion of the curve shown in Fig. 3(*a*).

All except three of the void ratio - pressure curves from the consolidation test investigations are included in Fig. 4. The three which were omitted were known to be faulty because irregular test procedures were used. While there is some spread in the curves from the series B specimens, a careful analysis showed that the variations are within the limits of error incident to laboratory techniques of measurement. Therefore it was concluded that these curves did not aid in discerning any differences in the slugs.

The plotted points of Fig. 5 represent laboratory time-compression data taken from parallel tests on two specimens

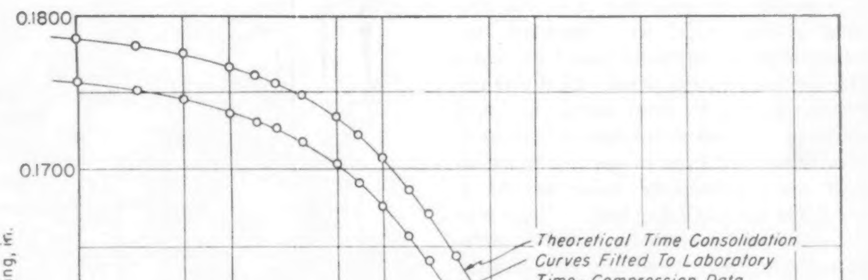


Fig. 5—Time-Consolidation Curves for Parallel Tests on Two Specimens from the Same Slug.

which were from the same slug. Theoretical time-consolidation curves, shown by the solid lines, have been fitted to these two sets of data and the agreement between the theoretical curve and the laboratory data is seen to be almost perfect until the beginning of the secondary branch. The vertical displacement between the two curves has no significance; had percentage of consolidation been used as a vertical ordinate instead of dial indicator readings, the two curves would have been almost coincident.

Evaluation of Test Results:

The results given in Figs. 3(*a*), 4, and 5 show that the test results on adjacent slugs were duplicated with a precision that was better than could be evaluated by very careful laboratory measurements. However, there were greater variations in the test results of slugs taken at random from each of the series. The unconfined compression test studies showed that these variations could be closely correlated with differences in the initial moisture content of the slugs. It is believed that with more careful control of the moisture content, as recommended previously, the variation in test results could be brought within the accuracy of careful laboratory measurement.

Rutledge has found that good tests on undisturbed samples give stress-strain curves that are straight lines up to 30 or 40 per cent of the maximum compressive stress.[2] Many investigators have shown that the stress-strain curves for completely remolded specimens have a definite curvature even at the very beginning. Figure 3(*b*) shows that the stress-strain curves from tests made on extruded slugs show an initial straight-line portion. Upon further examination it may be seen that this straight-line portion fulfills Rutledge's criterion for a good undisturbed sample. The sharp curvature in the transition zone between the initial straight-line portion and the final horizontal portion of the curves shown in Fig. 3(*a*) is not typical of the ordinary remolded soil. The shape of the void ratio - pressure curves shown in Fig. 4 also indicates that extruded samples do not conform to ordinary remolded samples. The knee of the curves is more abrupt and in addition the straight-line portion of the curves is seen to be slightly concave upward. While this has been noted frequently to be a characteristic of good undisturbed samples, it is never found in results of tests on remolded clays.

Natural soil samples taken from below permanent ground-water level are usually found to have a high degree of saturation. It is believed that the vacuum extrusion method affords the only means of obtaining high degrees of saturation without molding at or near the liquid limit and thus sacrificing the relatively stiff consistency of many natural soil samples.

It is not to be inferred that extruded samples can in any way duplicate naturally formed soil structures. However, the extrusion method does furnish excellent laboratory copies having many of the characteristics of natural soils. They can also be handled, prepared, and tested with techniques that are similar to those used on natural soils. This makes extruded specimens particularly well adapted to investigations of variables in test procedures, to the evaluation of new test procedures, and to the evaluation of new test equipment.

Regardless of the advantages incident to the degree to which extruded slugs may simulate natural clays, their high degree of saturation is extremely desirable from the standpoint of duplicating the ideal assumption of complete saturation that is frequently made in theoretical developments. Development and dissipation of pore-water pressures in soil specimens are critically affected by the initial degree of saturation, and since pore-water pressures have an important effect on the strength properties of soils, it is believed that the high degree of initial saturation of extruded slugs will greatly aid in experimental investigation of theoretical relations. The value of extruded specimens for such purposes is borne out by the very close fit shown between theoretical and laboratory time-consolidation curves in Fig. 5.

While most soil investigations require specimens with a high degree of saturation, it is believed that extruded specimens with lower degrees of saturation might be manufactured by reducing the vacuum pressure during the extrusion process. In this manner, specimens could be manufactured for an investigation of the effects of the inital degree of saturation upon the initial portion of the time-compression curve in consolidation testing and for investigation of the effects of the degree of saturation upon the compressive strengths of clays.

Another application for which extruded samples would be particularly well suited would be in the investigation of thixotropic stiffening of clays. The uniformity of extruded samples would greatly aid in the detection of trends which might be only partially developed within the time available for such tests.

Extruded samples have served a very practical purpose at The University of Texas during the past three years by furnishing a convenient stock of samples for routine class work. While they do not replace natural samples of soils for development of a student's familiarity with different soil structures, they are valuable in teaching testing techniques and procedures, and they enable accurate comparisons of student test results.

Conclusions

It has been shown that extruded clay specimens can be molded with a high degree of saturation while at the same time the relatively stiff consistencies associated with most undisturbed soil specimens are maintained. Because these extruded specimens can be duplicated with an accuracy which is not possible through the use of any previously available method of forming remolded specimens, test results can be duplicated with a high degree of precision.

Some of the physical characteristics previously evidenced only by good undisturbed samples are developed by the extrusion method, probably largely because of the high degree of saturation attained. Extruded specimens cannot be expected to duplicate the properties of highly sensitive, naturally deposited clays.

Extruded specimens can become very accurate and valuable tools for many types of laboratory research and for the evaluation of new test procedures and equipment. Because of the increased accuracy of test results, many laboratory investigations can be completed with a considerable saving in time and in the amount of testing necessary to produce conclusive results.

[2] Philip C. Rutledge, "Relation of Undisturbed Sampling to Laboratory Testing," *Transactions*, Am. Soc. Civil Engrs., Vol. 109, pp. 1169–1174 (1944).

Calculation of Air Bubble Size Distribution from Results of a Rosiwal Traverse of Aerated Concrete

By G. W. Lord[1] and T. F. Willis[1]

Synopsis

Several characteristics of the dispersed air bubbles in aerated concrete have been indicated as important to the study of the function, and intelligent use, of entrained air. This paper describes a method of calculation, together with its graphical derivation, by means of which various parameters characterizing the dispersed air phase may be obtained from measurements made in a modified Rosiwal microscopic traverse. Also included is an appendix in which the method is derived in more formal mathematical terms. While originally developed for study of concrete, the method is applicable to any system containing spherical dispersoids which can be examined by the Rosiwal linear traverse technique. A sample calculation showing results for a specimen of concrete is included.

The widespread use of air-entraining agents in concrete has made it desirable to be able to determine the quantity of air in the hardened concrete. Verbeck (1)[2] proposed and described the use of the "Camera Lucida" method for determining the proportion of air in concrete. This method has several operational defects, chief of which is the tediousness of drawing and planimetering the large number of bubble sections necessary to insure that a representative sample of the entire size range has been examined. Rexford (2) pointed out, and Brown and Pierson (3) described in detail the application of the Rosiwal (4) linear traverse method to the determination of the air content of hardened concrete. The method has now been used sufficiently to show that it is well suited to this purpose. Recently, however, Powers (5) developed a hypothesis which indicates that other definitive characteristics of the air-bubble phase may be fully as important as the quantity of air in the concrete. These characteristics are dependent on the air-bubble size distribution.

In an attempt to apply the Rosiwal technique to determination of parameters of the dispersed air phase from which bubble size distribution could be calculated, Willis (6) assumed a hypothetical system as being representative of the experimental application of this technique to the examination of aerated concrete. The hypothetical system contained a continuous size distribution of randomly placed spherical dispersoids and was penetrated by a random line. By application of the principles of mathematical probability, he derived equations relating the moments of the distribution of chord lengths (obtained in a modified Rosiwal traverse, in which the length of each chord intercepted by a sphere is measured and recorded) to moments of the distribution of the actual diameters of the spherical dispersoids. By means of these equations, the original Rosiwal relation for determining the proportion of the total volume occupied by the disperse phase was verified; and also a simple relation for determining the specific surface of the disperse phase was derived.

Unfortunately, even with data on the length of each individual chord available, Willis failed at that time to see any way of applying the derived equations to calculation of other desired parameters of the system, such as the mean sphere diameters and the number of spheres per unit volume. The present dissertation describes a method of calculation,[3] and its graphical derivation,[4] by means of which an approximation of bubble-size distribution and these other quantities may be obtained. The derivation is made in three steps: first, the relation between a known distribution of sphere diameters and the expected chord-length distribution is developed graphically; second, this graphical relation is used to develop the relation between a known chord-length distribution and the expected sphere diameter distribution; and, finally, the steps of the arithmetic calculation are outlined and actually carried out for measurements made in a modified Rosiwal traverse of a concrete specimen.

Chord-Length Distribution to be Expected from a Known Distribution of Sphere Diameters

1. The so-called frequency distribution curve of any variable is constructed by plotting the frequencies, with which each magnitude of the variable occurs, against the magnitudes. It is an inherent characteristic of such a curve that the area underlying it is proportional to the total number of occurrences of all the magnitudes of the variable.

2. For a system containing a large number of spheres having a continuous size distribution and dispersed in a unit cubical volume, it has previously been shown (7) that if such a system is penetrated by a random line,

$$\phi(l)\,dl = \frac{2l\,dl}{[u]_2}\int_l^U F(u)\,du \quad \ldots\ldots (1)$$

where:

$\phi(l)\,dl$ = the probability that any specific chord, intercepted by a sphere, has a length between l and $l + dl$,

$[u]_2$ = the second moment of the distribution of sphere diameters and

$\int_l^U F(u)\,du$ = the relative number of spheres in the system having diameters between l and U.

From which,

$$\phi l = \frac{2l}{[u]_2}\int_l^U F(u)\,du \quad \ldots\ldots (2)$$

For a system containing a large number of spheres of *uniform* size

$$\phi(l) = kl$$

since for such a system $[u]_2 = u^2 = a$

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

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[2] Boldface numbers in parentheses refer to the list of references appended to this paper, see p. 60.

[3] G. W. Lord originally conceived the derivation of this method, and it is here presented, in terms of the geometry of figures representing the distribution of chord lengths which would be expected from a linear traverse of a system of spheres having a discontinuous distribution of diametrical magnitudes. In a private communication, R. E. Philleo, Assistant Research Engineer, Portland Cement Assn., has disclosed a method—arrived at independently—based on the graphical solution of two of the fundamental differential equations relating chord length to actual diameter for a continuous distribution of sphere diameters. Applied to the empirical data obtained from a linear traverse, the two methods give essentially the same results.

[4] The method can also be derived by evaluating the left-hand side of Eq 2 for fixed intervals of chord lengths and calculating approximate solutions of the resulting system of integral equations. To a trained mathematician the resulting derivation is probably simpler than that given herein; however, in the authors' opinion, the physical significance would not be as easily grasped by the majority of individuals who will have occasion to use the method. (See Appendix.)

constant, and $\int_l^u F(u)\,du$ = a constant. The function, $\phi(l)$, is the probability density of l and should approximate the relative frequency function of measured chord lengths. Multiplying both sides of the equations by $\Sigma(\Lambda)$, the total number of chords per unit length of traverse,

$$\phi(l)\,\Sigma(\Lambda) = k\Sigma(\Lambda)l = Kl$$

since for any specific system $\Sigma(\Lambda)$ is a constant. $\phi(l)\Sigma(\Lambda)$ then gives the actual frequency of occurrence of chords of various lengths. The graph of the frequency distribution of chord lengths, resulting from penetration of this system, is then a straight line increasing from 0 to a maximum at $l = u_1$ (since no chord can be longer than the diameter of the spheres), as illustrated in Fig. 1(*a*).

3. For such a system, it has been previously pointed out (**8**) that the expected number of spheres penetrated, and equivalently the expected number of chords resulting from penetration of spheres, is proportional to the square of the diameter of the spheres, and also to the number of spheres in the system; that is, for a system of unit volume containing n_1 spheres of diameter u_1, which system is penetrated by a random line,

$$\Lambda_1 = \frac{\pi}{4}\, n_1 u_1^2$$

where Λ_1 = the number of chords per unit length of penetrating line.

4. Summarizing the foregoing, for a system containing spheres of a single size penetrated by a random line, the graph representing the distribution of chord lengths must satisfy two requirements:

(*a*) The distribution curve must be a straight line increasing from 0 to a maximum at $l = u$, at which point it drops perpendicularly to 0.

(*b*) The total number of chords, and hence (from paragraph 1 above) the triangular area under the chord-length frequency distribution curve, must be proportional to the number of spheres per unit volume of the system and also to the square of the sphere diameter, the constant of proportionality being $\pi/4$.

5. To meet these requirements, the expected frequency distribution curve of chord lengths from a uni-size system of spheres is constructed as follows:

(*a*) In Fig. 1(*a*), let the ordinates represent number of chords, and the abscissae length of chords in the desired units.

(*b*) At any point, *A*, on the horizontal axis, erect a perpendicular *AB*.

(*c*) On *AB*, lay off $\overline{AB} = (\pi/2)\,\overline{OA}n_1 = Kn_1$.

(*d*) Draw *OB*.

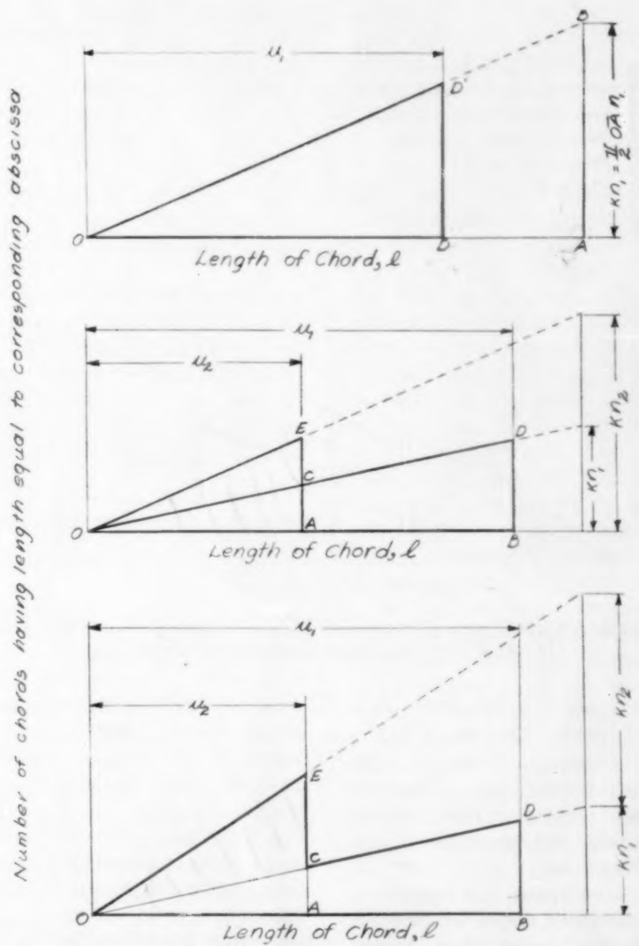

Fig. 1.—Expected Number of Chords of Various Lengths Resulting from Penetration by a Random Line of Various Systems of Spheres.

(*e*) At point *D*, where $l = u_1 = \overline{OD}$ erect a perpendicular *DD'*.

(*f*) From the two similar triangles, *ODD'* and *OAB*,

$$\frac{\overline{DD'}}{\overline{AB}} = \frac{\overline{OD}}{\overline{OA}}$$

But

$$\overline{AB} = \frac{\pi}{2} n_1\,\overline{OA},$$

and

$$\overline{OD} = u_1;$$

then

$$\overline{DD'} = \frac{\pi}{2}\, n_1 u_1,$$

(*g*) from which the area of

$$\overline{ODD'} = \frac{1}{2}\, u_1\,\overline{DD'} = \frac{\pi}{4}\, n_1 u_1^2.$$

(*h*) Then the line *OD'D* will represent the frequency distribution curve of chord lengths since it meets the requirements stated in paragraph 4 above.

6. The above exposition would apply to any system containing dispersed spheres of uniform size, regardless of the values of *n* and *u*. Consider two systems of spheres, one system made up of n_1 spheres of diameter u_1; and the other, of n_2 spheres of diameter u_2. The frequency distribution curve for chord lengths resulting from penetration of spheres of diameter u_1 would be representable by the curve *ODB;* that for chord lengths from spheres of diameter u_2 by the curve *OEA* in Fig. 1(*b*).

7. If the two systems are combined into one, the total number of chords having a length of 0 to u_2 would be the sum of the triangular areas $\overline{OCA}$ and $\overline{OEA}$ in Fig. 1(*b*); and the number of chords having lengths between u_2 and u_1 would be the trapezoidal area $\overline{ACDB}$. Then the chord-length frequency distribution curve for the combined system must enclose an area equal to the sum of the two triangles and the trapezoid; and each element of the area must be positioned so that its ordinate represents the combined number of chords having a length equal to its abscissa. The curve would be the line *OECDB* in Fig. 1(*c*). This is constructed by laying off *EC* in Fig. 1(*c*) equal to *AE* in Fig. 1(*b*). Considering these as the bases of the triangles, it is obvious that $\overline{\Delta OEC}$ in Fig. 1(*c*) and $\overline{\Delta OEA}$ in

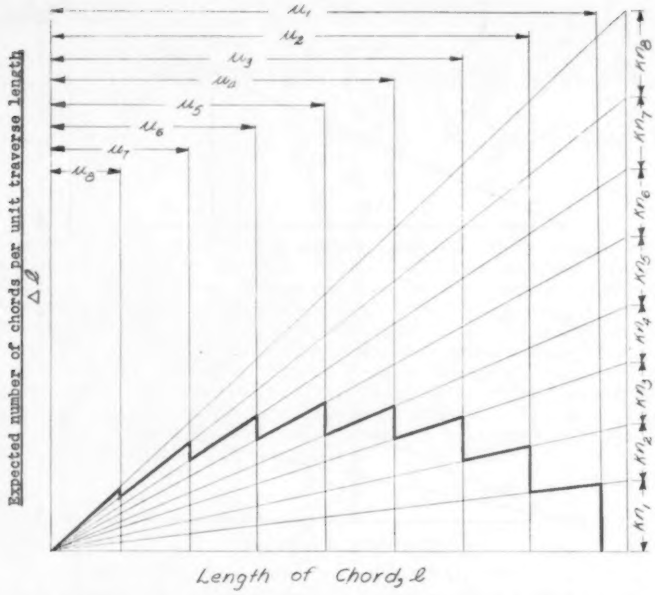

Fig. 2.—Expected Chord-Length Distribution Curve Resulting from a System of Spheres Having a Distribution of Diametral Magnitudes.

Fig. 1(*b*) have equal areas since their altitudes and bases are equal; also the triangles $\overline{OCA}$ are identical in both figures. Furthermore the distances Kn_1 and Kn_2, representing the numbers of each sphere size, are, respectively, the same in both figures.

8. In the same manner, a frequency distribution curve of chord lengths resulting from penetration of a system containing numerous sizes of spheres may be constructed (such as Fig. 2) in which the number of chords from each size of sphere contributes a triangular area, the dimensions of which are dependent on the diameter and number of spheres in the size group.

Determination of the Probable Distribution of Sphere Diameters from an Empirical Distribution of Chord Intercepts

9. In performing a Rosiwal traverse it is possible to modify the procedure so that the length of each intercepted chord is measured. If this be done and the number of chords falling in each (relatively small) length interval is recorded, an approximate frequency distribution curve of chord lengths can be constructed by plotting numbers of chords per length interval as ordinates against the medians of the corresponding length intervals. In Fig. 3, assume the points $I'H'G'$, etc., to represent such a plot. Connect the origin and each of these points with a line and extend these lines until they intersect the line AJ, located $\overline{OA}$ units from the origin.

10. If the chord-length intervals are small it may be assumed that, of each sloping line joining the origin and the ordinate representing number of chords in an interval, the segment lying between the limits of the interval represents the distribution of chord lengths within the interval. For instance in Fig. 3 the heavy line segment between 0 and $l = u_8$ is assumed to represent the distribution of chord lengths having values between $l = 0$ and $l = u_8$. Then the entire heavy line in Fig. 3 approximates the true chord-length frequency distribution curve for the complete linear traverse.

11. As previously shown in paragraph 7 the vertical distances along AJ will be

$$\overline{AB} = Kn_1$$
$$\overline{BC} = Kn_2$$
$$\overline{CD} = Kn_3 \quad \text{etc.}$$

If the line AJ is placed so that $\overline{OA} = 2/\pi$ units on the l scale, it can be shown that $K = 1$, and from Fig. 3.

$$\tan AOB' = \frac{\overline{B'B_1}}{\overline{OB_1}},$$

$$\tan AOC' = \frac{\overline{C'C_1}}{\overline{OC_1}},$$

etc., to

$$\tan AOI' = \frac{\overline{I'I_1}}{\overline{OI_1}}.$$

Also

$$\overline{AB} = Kn_1 = n_1 = \tan AOB' \times \overline{OA} = \frac{2}{\pi}\frac{\overline{B'B_1}}{\overline{OB_1}}$$

$$\overline{AC} = n_1 + n_2 = \tan AOC' \times \overline{OA} = \frac{2}{\pi}\frac{\overline{C'C_1}}{\overline{OC_1}}$$

etc. Finally

$$\overline{AI} = n_1 + n_2 + \ldots n_8 = \tan AOI' \times \overline{OA} = \frac{2}{\pi}\frac{\overline{I'I_1}}{\overline{OI_1}} \quad (3)$$

Arithmetic Calculation of Sphere-Diameter Distribution

12. The arithmetic calculation of the sphere-diameter distribution from the observed chord-length distribution is relatively simple. The first step is to calculate, for each group of chord lengths, the ratio of the number of

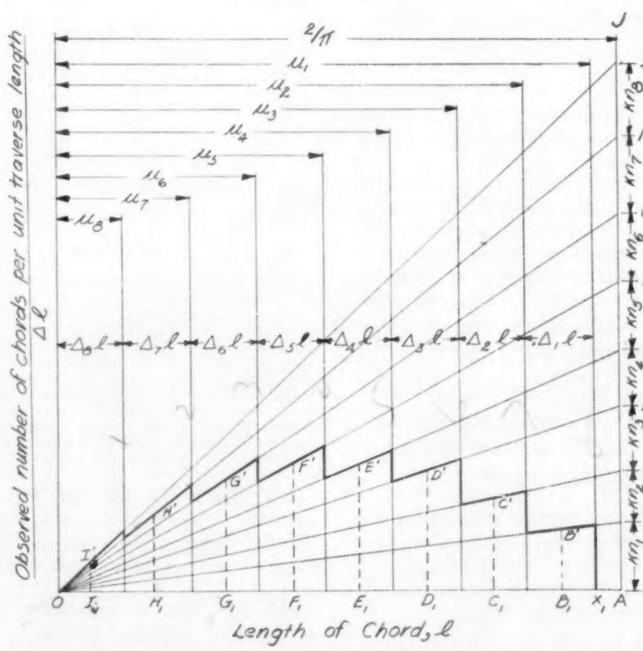

Fig. 3.—The Relation of an Empirical Chord-Length Distribution to the Probable Distribution of Sphere Diameters.

chords in the group to the median value of the chord-length group. Starting with this ratio for the group with the smallest median value, subtract from it the ratio for the group with the next larger median and multiply the difference by $2/\pi$. The result is the expected value for the number of spheres having a diameter equal to the magnitude of the upper limit of the first chord-length interval.

For example in Fig. 3

$$\frac{2}{\pi}\left(\frac{\overline{I'I_1}}{\overline{OI_1}} - \frac{\overline{H'H_1}}{\overline{OH_1}}\right) = \text{the number of spheres of diameter } u_8 \text{ in the system}$$

$$\frac{2}{\pi}\left(\frac{\overline{H'H_1}}{\overline{OH_1}} - \frac{\overline{G'G_1}}{\overline{OG_1}}\right) = \text{the number of spheres of diameter } u_7, \text{ etc.}$$

It is obvious that the smaller the chord-length intervals, limited of course by the accuracy of the measuring device, the more nearly the calculated distribution will approach the actual distribution of sphere diameters.

Table I presents the data on the chord-length distribution obtained from performance of a modified Rosiwal traverse on a 4½ by 16-in. section of a specimen of concrete,[5] also the calculated data necessary to determine the expected bubble diameter distribution. By combining some of the constant factors, the end result can be achieved with fewer arithmetical operations; however, to assist in explaining the method all intermediate steps are included.

The total number of spheres per unit volume of the concrete may, of course, be obtained by summation of the values in column 7.

13. The graphical derivation clearly indicates a very simple method for calculating this summation. Inspection of Fig. 3 shows that it should be obtainable by dividing the ordinate of the group of shortest chord length by the median and multiplying by $2/\pi$, that is,

$$\text{Total number of spheres per unit volume of concrete} = M = \overline{AI} = \frac{\overline{I'I_1}}{\overline{OI_1}} \times \frac{2}{\pi}$$

In actual practice, however, it will often be found that the ordinate of this chord-length group has a value less than theory dictates it should have, indicated by the ordinate, $\overline{I'I_1}$, being such that the angle AOI is less than the angle AOH. This is obviously impossible if the measurements and observations are correct. Such an inconsistency is readily explainable on the basis that the observer failed to recognize and enumerate some of the shortest chords. In this laboratory, measurement of chords falling in the length interval 5 to 15 μ is attempted. The stereoscopic microscope, however, has a limit of resolution of about 8 to 10 μ; hence, the possibility of error in this range is obvious. When it occurs, the ordinate of the next to the smallest chord-length interval is used to calculate an approximation of the total number of spheres.

14. Having obtained the sphere-diameter distribution, it is of course possible to calculate any of the mean diameters of the system of spheres such as the arithmetic mean diameter, the diameter of the sphere having mean surface area, or the diameter of the sphere having mean volume. Any of these may serve to characterize the system or provide the basis for determining other useful properties. In Table II, several parameters of the system analyzed in Table I are shown.

15. In closing, a word of caution might not be amiss. What has been described in this paper is only a method of calculation. Results obtained with it can be no more accurate than are the measurements supplying the data to which the method is applied. Furthermore, as in the solution of any problem by statistical methods, the empirical data of the sample should uniquely represent the particular statistical universe being sampled; the larger the sample, the more nearly this condition

[5] Method and apparatus are described by Brown and Pierson (3) and a discussion of their paper by T. F. Willis to be published in the *Journal* of the Am. Concrete Inst.

TABLE I.—SAMPLE CALCULATION OF SPHERE-DIAMETER DISTRIBUTION.

(1) Chord-Length Interval in Revolutions	(2) Number of Chords Observed in Interval	(3) $\frac{\Lambda}{\Delta l}$, cm	(4) Median of Chord-Length Interval, cm	(5) $\frac{\Lambda}{\Delta l} \div l$	(6) Successive Differences of Column 5	(7) Number of Spheres per cu cm	(8) Diameter of Spheres, cm
0.05–0.15......	66	109.69	0.002116	51 838	5 104	3 249	0.003174
0.15–0.25......	119	197.78	0.004232	46 734	22 648	14 418	0.005290
0.25–0.35......	92	152.90	0.006348	24 086	9 751	6 207	0.007406
0.35–0.45......	73	121.33	0.008464	14 335	4 753	3 026	0.009522
0.45–0.55......	61	101.38	0.010580	9 582	3 037	1 933	0.011638
0.55–0.65......	50	83.10	0.012696	6 545	2 057	1 309	0.013754
0.65–0.75......	40	66.48	0.014812	4 488	1 445	920	0.015870
0.75–0.85......	31	51.52	0.016928	3 043	1 036	660	0.017986
0.85–0.95......	23	38.23	0.019044	2 007	594	378	0.020102
0.95–1.05......	18	29.92	0.021160	1 413	342	218	0.022218
1.05–1.15......	15	24.93	0.023276	1 071	253	161	0.024334
1.15–1.25......	12.5	20.78	0.025392	818	153	97.4	0.026450
1.25–1.35......	11.0	18.28	0.027508	665	87	55.4	0.028566
1.35–1.45......	10.3	17.12	0.029624	578	80.6	51.3	0.030682
1.45–1.55......	9.5	15.79	0.031740	497.4	65.3	41.6	0.032798
1.55–1.65......	8.8	14.63	0.033856	432.1	94.9	60.4	0.034914
1.65–1.75......	7.3	12.13	0.035972	337.2	49.2	31.3	0.037030
1.75–1.85......	6.6	10.97	0.038088	288.0	44.0	28.0	0.039146
1.85–1.95......	5.9	9.81	0.040204	244.0	91.9	58.5	0.041262
1.95–2.45......	21.3	7.08	0.046552	152.1	67.5	43.0	0.051842
2.45–2.95......	14.7	4.89	0.057132	85.6	59.4	37.8	0.062422
2.95–4.95......	26.4	2.19	0.083582	26.2	17.0	10.8	0.104742
4.95–6.95......	13.9	1.16	0.125902	9.2	5.6	3.6	0.147062
6.95–8.95......	7.3	0.61	0.168222	3.6	3.0	1.9	0.189382
8.95–10.95.....	1.5	0.12	0.210542	0.6	0.6	0.4	0.231702
						33 000.4	

Column 1: 1 revolution 0.02116 cm.
Column 2: these figures are the observed values for entire traverse length of 284.3434 cm.
Column 3: $\frac{\Lambda}{\Delta l} = \frac{\text{column 2} \div 284.3434}{[\text{difference in figures in column 1} \times 0.02116]} = \frac{0.1662 \times \text{column 2}}{[\text{difference in figures in column 1}]}$
Column 4: [median of figures in column 1 × 0.02116].
Column 5: column 3 ÷ column 4.
Column 6: value in column 5 less value for next larger size (on line below).
Column 7: column 6 × $2/\pi$ = column 6 × 0.6366.
Column 8: upper limit shown in column 1 × 0.02116.

TABLE II.—CHARACTERISTIC PARAMETERS CALCULATED FROM DATA IN TABLE I.

Air content of plastic concrete, per cent	5.39[a]
Air content of hardened concrete, linear traverse, per cent	5.20[b]
Arithmetic mean bubble diameter, cm	8.04×10^{-3}
Diameter of bubble having mean surface area, cm	10.12×10^{-3}
Diameter of bubble having mean volume, cm	14.56×10^{-3}
Specific surface, sq cm per cu cm	198
Number of bubbles per cu cm of concrete	33,000[c]

[a] Air meter measurement on entire specimen.

[b] Calculated from:

$$\frac{\text{Total of chord lengths}}{\text{Total traverse length}} \times 100 = \frac{14.78}{284.38}.$$

[c] Σ of column 6 in Table I or $2/\pi$ times top value in column 5.

is approached. For the linear traverse method, this means that the longer the traverse, the more closely the data approach statistical perfection. When determination of the air content of the concrete is the only objective, it appears that the 100-in. traverse and the microscopic equipment suggested by Brown and Pierson (**3**) are satisfactory. Further experimentation is necessary before the same conclusion can be applied to determination of other parameters of the air-bubble system. With this in mind the magnitudes in Tables I and II should presently be considered as approximations, the accuracies of which are unknown.

References

(**1**) George J. Verbeck, "The Camera Lucida Method for Measuring Air Voids in Hardened Concrete," *Journal*, Am. Concrete Inst., May 1947; *Proceedings* Vol. 43 p. 1025.

(**2**) Elliot P. Rexford Discussion of a paper by George Verbeck: "The Camera Lucida Method for Measuring Air Voids in Hardened Concrete." *Journal*, Am. Concrete Inst., Vol. 43 pp. 1040–1041 (1947).

(**3**) L. S. Brown and C. U. Pierson "Linear Traverse Technique for Measurement of Air in Hardened Concrete" *Journal*, Am. Concrete Inst., Vol. 47, pp. 117–123 (1950).

(**4**) A. Rosiwal, Verhandl K-k geol. Reichanstalt (1898), p. 143.

(**5**) T. C. Powers, "The Air Requirement of Frost Resistant Concrete," *Bulletin 33*, Research Laboratories of the Portland Cement Assn., p. 7; also in *Proceedings*, Highway Research Board, Vol. 29, pp. 189–190 (1949).

(**6**) T. F. Willis Discussion of a paper by T. C. Powers: "The Air Requirement of Frost Resistant Concrete" *Bulletin 33*, Research Laboratories of the Portland Cement Assn., pp. 20–28, 1950; also *Proceedings*, Highway Research Board, Vol. 29, pp. 203–211 (1949).

(**7**) T. F. Willis, *Ibid.*, 3rd equation in column 2 of p. 23 or p. 206.

(**8**) T. F. Willis, *Ibid.*, eq 39.

APPENDIX

The method of calculation described in the paper may also be derived[6] by substituting values, for the number of chords in arbitrary chord-length intervals, into the basic integral equation, thus obtaining a series of equations. By differencing these equations, expressions are obtained from which the numbers of spheres, having diameters between known finite limits, may be evaluated in terms of the numbers of chords occurring in definite chord-length intervals. To a trained mathematician this is the simplest derivation; in the authors' opinion, however, most users of the method will more readily grasp the fundamental relation between chord-lengths and sphere diameters from the geometrical derivation than from the more formal mathematical presentation. For those who may prefer it, the latter is detailed below.

Equation 43 in reference 6 pertains to a theoretical mathematical model which purports to represent the experimental application of the linear traverse technique to the examination of the air bubble system in aerated concrete. It states that:

$$\phi(l) = \frac{2l}{[u]_2} \int_l^U F(u)\, du \ldots\ldots (4)$$

where

$\phi(l)$ = the probability density for the occurrence of chords of length l.

$[u]_2$ = the second moment of the distribution of sphere diameters, and

$\int_l^U F(u)\, du$ = the proportion of the total number of spheres in the system having diameters between l and U, the latter being the maximum size of sphere in the distribution.

Letting l_i, with i being successively equal to 0, 1, 2, ... k, represent arbitrary magnitudes of l such that $l_0 = 0 < l_1 < l_2 \ldots . < l_k < U$, and letting a_i represent the magnitudes of l which are the medians of successive class intervals such as $(l_0, l_1), (l_1, l_k) \ldots (l_k, U)$, then

$$0 < a_0 < l_1 < a_1 < l_2 \ldots . < a_{k-1} < l_k < a_k < U$$

By substituting the various magnitudes of l represented by a in Eq. 1 a series of equations will be obtained, such as

$$\frac{[u]_2}{2} \frac{\phi(a_k)}{a_k} = \int_{a_k}^U F(u)\, du \ldots . (5)$$

$$\frac{[u]_2}{2} \frac{\phi(a_{k-1})}{a_{k-1}} = \int_{a_{k-1}}^U F(u)\, du \ldots . (6)$$

and so on.

Differencing consecutive pairs of these equations will yield another set of equations of which the following is an example:

$$\frac{[u]_2}{2} \left[\frac{\phi(a_k)}{a_k} - \frac{\phi(a_{k-1})}{a_{k-1}} \right] = \int_{a_k}^U F(u)\, du - \int_{a_{k-1}}^U F(u)\, du = \int_{a_k}^{a_{k-1}} F(u)\, du .. (7)$$

the right-hand member of which is the area under the sphere-diameter distribution curve from $u = a_{k-1}$ to $u = a_k$ and hence is proportional to the relative number of spheres having diameters between a_{k-1} and a_k.

The parameter $[u]_2$ may be evaluated as follows:

From reference 6, Eq. 41,

$$\sum(\Lambda) = \frac{\pi}{4} [u]_2 M \ldots\ldots (8)$$

where

$\sum(\Lambda)$ = total number of chords of all lengths per unit length of traverse, and

M = total number of spheres per unit volume of specimen.

Then

$$[u]_2 = \frac{4}{\pi} \frac{\sum(\Lambda)}{M} \ldots\ldots (9)$$

Substituting into Eq. 7

$$\frac{2}{\pi} \sum(\Lambda) \left[\frac{\phi(a_k)}{a_k} - \frac{\phi(a_{k-1})}{a_{k-1}} \right] = M \int_{a_{k-1}}^{a_k} F(u)\, du .. (10)$$

Assuming the *a priori* model to truly represent the experimental conditions in a Rosiwal traverse of aerated concrete,[7] the left-hand side of the expression may be evaluated by substitution of the appropriate empirical data and is an estimate of the actual number of spheres having diameters in the interval bounded by the limits of the integral. Similarly the entire sphere diameter distribution may be estimated from the observed numbers of chords in the other chord-length intervals.

If one is interested only in the number of spheres per unit volume, an approximation of this may be obtained—without calculating the sphere diameter distribution—from the number of chords in the smallest size group. From Eq. 4

$$\frac{\phi(a_0)}{a_0} = \frac{2}{[u]_2} \int_{a_0}^U F(u)\, du \ldots . (11)$$

Since $\int_0^U F(u)\, du = 1$ and since a_0 is the size-class median of smallest magnitude, $a_0 \to 0$ and $\int_{a_0}^U F(u)\, du \to \int_0^U F(u)\, du$ and is approximately equal to 1.

[6] The authors are indebted to Mr. Jerome Cornfield of the National Cancer Institute for pointing out this possibility; and also to L. T. Murray, Associate Research Engineer, Missouri State Highway Department, for assistance in formulating the equations involved.

[7] Linear traverses of specimens of hardened cement paste containing dispersed spherical glass beads of known size distribution have indicated this to be a valid assumption.

Then

$$\frac{\phi(a_0)}{a_0} \simeq \frac{2}{[u]_2} \qquad (12)$$

and from Eqs. 9 and 12

$$M \simeq \frac{2}{\pi}\frac{\phi(a_0)}{a_0}\sum A$$

Obviously, the smaller the upper limit of this smallest size group, the smaller the magnitude of a_0 and the closer $\int_{a_0}^{U} F(u)\, du \rightarrow \int_0^U F(u)\, du$; hence the better the approximation of the total number of spheres in the system. In application, the accuracy of the chord-measuring device will determine the smallest practical value of the upper limit of the smallest size group.

A Test of a Prestressed Concrete Beam

By G. S. Finley,[1] H. L. Morrison,[2] and H. S. Ragan[3]

The tests described in this paper were carried out at the University of Alberta during the winter of 1949–1950 as a preliminary investigation on prestressing of concrete beams using high-strength steel wires bonded to the concrete. It was desired to accumulate first-hand knowledge and data on the subject in order to point the way for further investigations in more specific fields.

One aspect of prestressed concrete which seems to have been overlooked in the literature to date is the determination of the actual stress in the wires or cables, and therefore emphasis was placed on this phase of the program. This was accomplished through the use of electric strain gages of the SR-4 type as later described.

A rectangular beam 8 by 13 in. in cross-section was constructed for a 10-ft clear span, to carry equal concentrated loads at the third points. These dimensions were chosen in order to provide a comparison with similar standard reinforced concrete beams for which data were available.

Figure 1 shows the beam in elevation and the cross-section of the beam at the centerline with the position of all strain gages indicated. The wires used had a diameter of 0.162 in. and a tensile strength of 225,000 psi.

The design of the beam was carried out along the lines suggested by Magnel.[4] Allowable stresses were assigned as follows: compressive stress in concrete 1330 psi, tension stress in steel 150,000 psi. At the time of testing, however, the average stress in the wires had fallen to 114,000 psi, and the maximum stress in the concrete was computed to be 870 psi. The main cause for the decrease in the allowable working stress in the prestressing steel and the accompanying decrease in the concrete stress was the crushing of the wooden form where it came in contact with the loading channels. A considerable loss was also observed when the form was removed. These losses are in addition to those that might be expected from creep in the steel and in the concrete.

Design figures (summary):

Section modulus of beam = 225 in.^{3}
Total area of steel 0.0206 × 20 = 0.412 in.^{2}
Average stress = 114,000 psi
Therefore prestressing force = 47,000 lb
Eccentricity = 2.00 in.
Moment due to prestressing = 94,000 in-lb

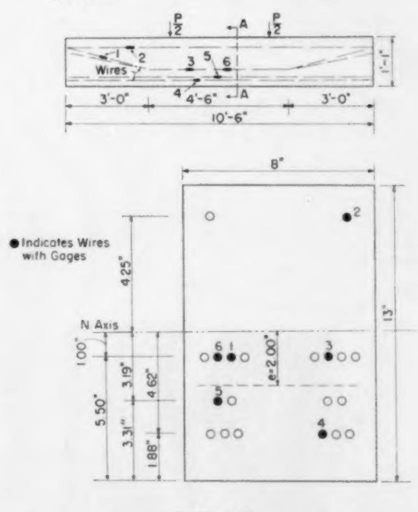

Fig. 1.—Showing Beams and Cross-Section with Position of All Gages Indicated.

Stress in bottom fiber

$$\frac{47{,}000}{8 \times 13} + \frac{94{,}000}{225} = 870 \text{ psi}$$

Add allowable tension stress and get total tension stress which may be induced in beam

$$870 + 120 = 990 \text{ psi}$$

Tension stress in bottom fiber due to dead weight

$$\frac{108 \times 10 \times 10 \times 12}{8 \times 225} = 72 \text{ psi}$$

Stress in bottom fiber due to applied load

$$990 - 72 = 918 \text{ psi}$$

Allowable moment

$$918 \times 225 = 207{,}000 \text{ in-lb}$$

Total (design) load therefore

$$\frac{2 \times 207{,}000}{40{,}000} = 10{,}350 \text{ lb}$$

A heavy timber form was constructed so that the wires could be put in tension within and against the form prior to placing the concrete. The prestressing load was carried by a 12-in. channel at each end of the beam as shown in Fig. 2. Figure 2(*a*) is a photograph of the channel against which the jack was placed for stretching the wires, and shows the grips which hold the wires after the jack has been removed and the wires cut off. The strain figures due to the breaking of the mill scale, and brought out by dusting with chalk, are clearly evident.

Figure 2(*b*) is a photograph of the channel at the opposite end of the beam from that in Fig. 2(*a*) showing how the wires were passed around the portion of 5-in. pipe and two pieces of 1-in. pipe which bear against the channel. When the forms were removed, these channels were left on the beam so that mechanical anchorage of the wire was also provided. Wires were passed through holes in the channel and gripped by a collar and wedge device supplied by the Preload Company of Canada. The prestressing was accomplished by stress-

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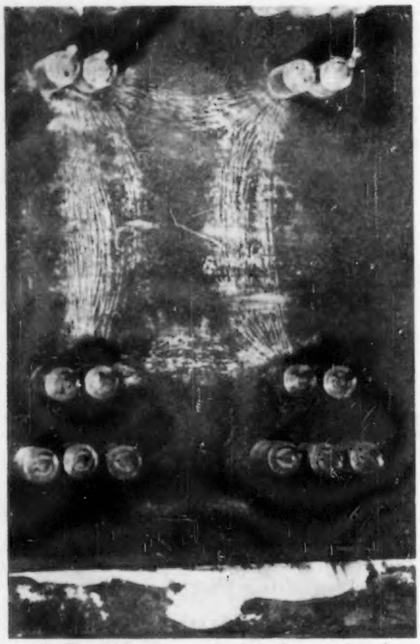
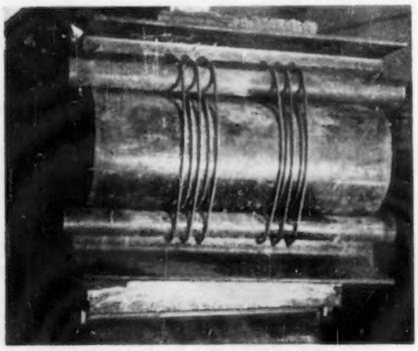
[4] G. Magnel, "Prestressed Concrete," Concrete Publications Limited, p. 19 (1948).



(a) Channel against which jack was placed.



(b) Channel at opposite end of beam.

Fig. 2.—Showing Channels at Ends of the Beam.

ing the wires in pairs, using a calibrated hydraulic jack as shown in Fig. 3. At the end remote from the jack, each wire was passed around a section of 5-in. pipe and returned through the beam. Before the concrete was placed, all wires were thoroughly cleaned with a commercial solvent.

The concrete used had a 28-day compressive strength of 4900 psi and a slump of 2 in.

Gages used to measure the strain in the wires were of the SR-4, electric resistance model, type A3.

These gages were not recommended for bar sizes smaller than ⅜ in. diameter, but because it was desired to keep a running check on the strain in the wires during curing and throughout the tests on the beam, and because this type of gage is comparatively easily waterproofed, an attempt was made to fasten these gages to the high-strength wire. Several tests were made on the assembly before it was finally adopted. From these tests, which were made by putting a sample of wire under tension, it was concluded that the gages as attached gave a very good measure of the strain.

The wire when unrolled assumed the shape of a helix about 4 ft in diameter. Due to the difficulty of holding a length of wire perfectly straight while attaching the gages, it was decided to fasten two gages, end to end and diametrically opposite, to each wire in order that an average of the readings would compensate for the curvature of the wire. The method of attaching the gages was as follows:

A 6-in. length of the wire was cleaned by rubbing with very fine emery cloth and the dirt removed with a cloth soaked in carbon tetrachloride. The paper backing of the gage was trimmed to about ½ in. width, just slightly larger than the red felt. A thin coat of Duco 5458 cement was applied to the gage and also to the wire. The gage was then aligned longitudinally on the wire and black No. 50 linen thread was wound firmly around in such a manner as to almost completely cover the felt.

The cement was allowed to harden for 24 hr before any further work was done on the gages. A piece of felt about 1 cm square was then glued on top of the gage as shown in Fig. 4, the gage wires were bent back over this and a second piece of felt was glued over the wires. Lead in wires were then soldered to the gage wires and secured to the prestressing wire. The wires were insulated from each other and all non-waterproof insulation was cut well back from the gages.

When complete, the assembly was given four coats of Durlok EC 711 waterproofing at 24-hr intervals. This was followed by a layer of Tygonite 15B cement which acted as a protective coating. (Since the original experiment the application of two coats of "Petrolast" has been found to be more satisfactory for the waterproofing and protection.)[5] The Tygonite was applied after the wires had been placed in the form and put in tension.

The concrete was placed using as stiff a mix as possible and tamping was done by hand. The effect on the gages of using a vibrator has not yet been determined.

From the start of applying tension to the wires, a record of the stress in six of the wires was kept. By the use of the strain gages it was possible to determine quite accurately the stresses in the individual wires as tightening was carried out. The technique finally evolved for this was as follows:

A pair of wires (really opposite ends of the same wire) was selected and attached to the stretching apparatus. The cross member (which was the other portion of the 5-in. pipe), see Fig. 3, was centered and the wires stressed to a point just below the assigned proportional limit of the steel (175,000 psi). This stress was maintained for two minutes and checked when possible by the use of the strain gages (twelve of the twenty wires were checked). The stress was then relaxed to approximately 160,000 psi and the wedges inserted and driven into the collars. The jack was then released. The pull-in of the wedges was noted to be about ⅛ in. which of course would remain constant no matter what the length of the beam might be. For this case, it represented a loss of stress of over 20,000 psi.

A record of the stress in the wires was kept with readings being taken each day until the beam was actually tested. This record is presented in Fig. 5, which shows the steel stress from the time of application of the stressing load. The varying stress for different wires should be noted. It is believed that this is due to a crushing of the wooden form where the end plates came in contact with it and also to a deflection of the end plate. The latter may be seen in Fig. 2(a) where the strain lines produced have been dusted with chalk. This deflection of the plate caused by stressing subsequent wires produced a relaxation of the wires already stretched. Gages No. 6 were on a wire which was gripped a second time and again stressed after all of the stretching process had been completed, thus explaining the small initial loss in tension.

The use of electric resistance strain gages in this test was based on the

[5] In applying the Petrolast, care must be taken that the gages are not overheated. It has also been found that pigmented aircraft dope is a good waterproofing agent, especially when applied over one coat of Petrolast. A portion of the latter is dissolved by the dope and gives a tough flexible surface.

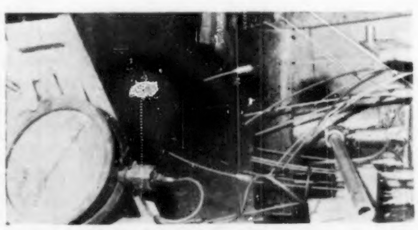


Fig. 3.—Calibrated Hydraulic Jack.

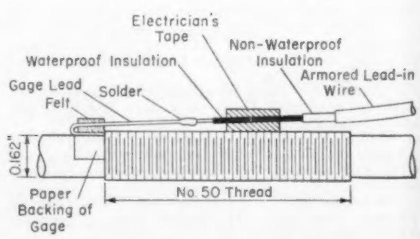


Fig. 4.—Strain Gage Assembly.

assumption that the creep in the steel would be small. Magnel has shown that with this procedure for stretching, the loss of stress due to creep will be of the order of 5 per cent.[6]

At 21 days the forms were removed and the prestressing load transferred to the concrete. This is indicated by the vertical trend of the graphs. Gages No. 2 were on a wire above the neutral axis of the beam.

It should be noted that the largest part of the loss in stress occurred during the first two days after stressing of the wires took place.

During the actual test, the beam was loaded at the third points. The total load was applied in 1000-lb increments. Several cycles of loading were run. These are not shown on the graph.

Figure 6 shows the curve for load *versus* deflection (as measured with an Ames dial), which is consistent with the usual curve obtained for prestressed beams.

Figure 7 shows the stress in the prestressing wires during the test. Gages No. 1 were on the neutral axis and therefore showed little change in stress until such time as the bond on the wire broke at a total load of 25,000 lb. Gages No. 2 were above the neutral axis and therefore showed a decrease in stress during the test.

Gages 3 to 6 were in the lower portion of the beam. It should be noted that there was very little change in stress in the wires until a total load of just over 15,000 lb was reached. At no time up to application of the design load did the stress rise above that originally applied to the wire. This points out one safety feature of prestressed construction. All of the prestressed wires are, in effect, tested before the beam can be completed. There is thus little chance for faulty materials to get into a member of this sort.

The first crack in the beam appeared at a total load of 16,000 lb and is indicated on the graphs by a discontinuity of the curves. As the load increased, this crack widened and other cracks of similar nature occurred. After the first crack appeared, the beam had lost its prestressed advantages and commenced to behave as a conventional reinforced beam with a marked increase in the steel stress with each increase in applied load.

Ultimate failure of the beam occurred at a total load of 33,600 lb. Failure was due to crushing of the concrete, as shown in Fig. 8.

Upon removal of the load, the beam recovered almost completely and the

[6] G. Magnel, "Creep of Steel and Concrete in Relation to Prestressed Concrete," *Journal*, Am. Concrete Inst., Vol. 19, No. 6, February, 1948, pp. 485–500; *Proceedings*, Vol. 44

Fig. 5.—Steel Stress *Versus* Time Since Stressing.

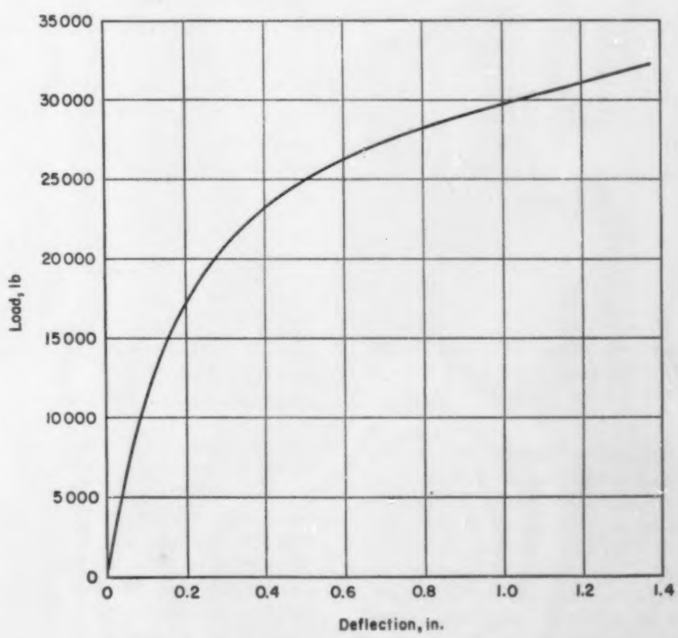


Fig. 6.—Curve Showing Load *Versus* Deflection.

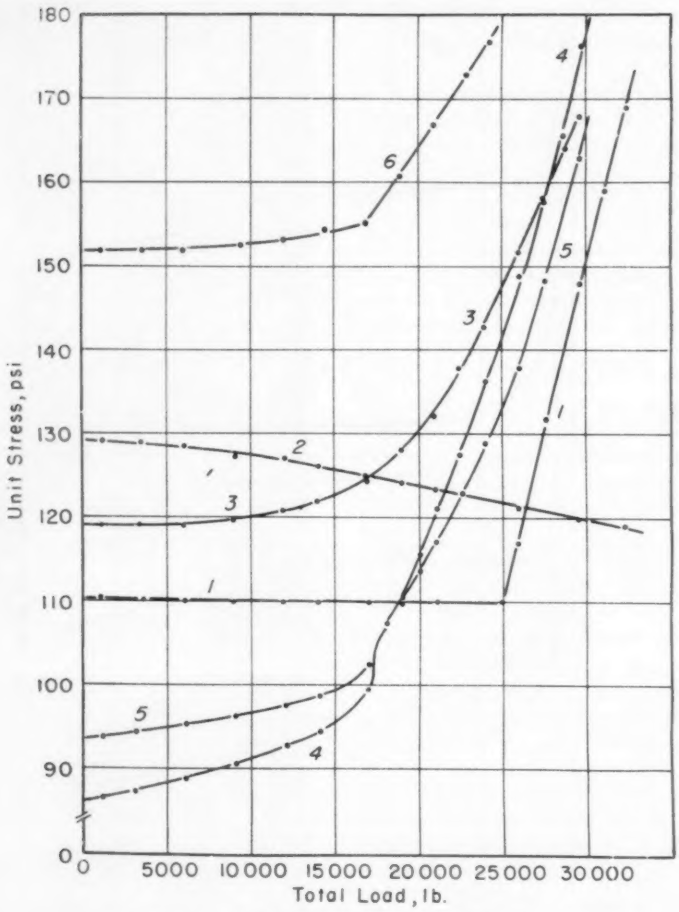


Fig. 7.—Stress in the Prestressed Wires During Test.

Fig. 8.—Showing Failure of Beam Due to Crushing of Concrete.

Fig. 9.—Showing Recovery of Beam After Removal of Load.

failure crack closed as shown in Fig. 9. The center deflection shortly before failure was 1.57 in. After failure, the beam was again capable of carrying the design load, with no apparent ill effects. The deflection recovery after failure was over 80 per cent of the maximum deflection.

After the test, upon removal of the channel end plates from the beam, it was noted that the wires were still held by bond near the ends, and still retained considerable stress. Gages Nos. 1 and 3 showed approximately 110,000 psi.

Results of this experiment would seem to indicate that the method of tensioning the wires is very satisfactory and that construction of prestressed members is feasible using fairly simple equipment.

Recovery of the beam after failure would indicate a high resistance to impact and overloading, such as might occur on a highway bridge.

Using the technique and experience gained from this experiment, further research in prestressing is now being undertaken at the University of Alberta with special emphasis on the bonding of wires.

Acknowledgment:

The authors wish to acknowledge at this time the kindness of the Preload Co. of Canada for supplying the high-strength wire and the gripping devices used during the experiment. They would also like to thank G. Ford of the Department of Civil Engineering, University of Alberta, and other members of the faculty for the valuable assistance which they rendered.

Building Research Advisory Board Report on Fire Resistance of Non-Load-Bearing Exterior Walls

THE Building Research Advisory Board, the newest member of the Division of Engineering and Industrial Research, National Research Council, has now published Report No. 2 on Fire Resistance of Non-Load-Bearing Exterior Walls, which is a record of the second research correlation conference it has sponsored. The topic selected, although limited to a specific detail in the construction of multistoried buildings, has been the subject of rather widespread controversy resulting from the new developments in the design and engineering of the wall and new materials for its construction. These new developments have presented problems which have concerned those interested in uniform and modern building codes and regulations. The conference brought together architects, engineers, manufacturers, and builders—the men who design and who are responsible for building construction.

The report presents a series of papers which were given at two sessions at the National Academy of Science on November 21, 1950. In these papers, it is noted that such items as the background of requirements for fire resistance, the viewpoint of the research director, the cost, the viewpoint of the code official, fire hazards, and new type wall construction are covered. Copies of this report are for sale by the Building Research Advisory Board, National Research Council, Washington 25, D. C., the cost being $3.50 for single copies. Quantity prices are quoted upon request.